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Socio-Economic Impact Evaluation of Lake Improvement Projects and Lake Management Guidelines

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SOCIO-ECONOMIC IMPACT EVALUATION OF LAKE IMPROVEMENT PROJECTS AND LAKE MANAGEMENT GUIDELINES

Prepared for the U.S. Environmental Protection Agency
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16. ABSTRACT

Under Public Law 92-500, the U.S. Environmental Protection Agency embarked on a major program of cost sharing grants to implement lake rehabilitation and protection projects. Improvement of water quality impacts the lives of people and organizations; however, the methods used to measure the impact of water quality projects on the socio-economic well-being of people and on the viability of organizations and communities is rudimentary in general and nonexistent with respect to this financial assistance program. A method is need to help select lake communities as recipients of state and federal grants and to evaluate the effectiveness of the project. To address these issues, the general objectives of this research were to: 1. Ascertain and evaluate the present and potential impact of two specific water quality improvement project on individuals, participating groups of recreationists, organizations, and communities. 2. Recommend substantive and procedural program changes to local lake districts, University of Wisconsin Extension, Wisconsin DNR and EPA. 3. Contribute to the development of a general method for social and economic evaluation of water quality improvement projects. Recommendations are presented in the report.

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CHAPTER 1

CONCLUSIONS AND RECOMMENDATIONS

Under Public Law 92-500, the U.S. Environmental Protection Agency (E.P.A.) embarked on a major program of cost-sharing grants to implement lake rehabilitation or protection projects. Improvement of water quality impacts the lives of people and organizations; however, the methods used to measure the impact of water quality projects on the socio-economic well-being of people and on the viability of organizations and communities is rudimentary in general and non-existent with respect to this new financial assistance program. A method is needed both to help select lake communities as recipients of state and federal grants and to evaluate the effectiveness of the project.

In an effort to address these issues the general objectives of this research were to:

1. Ascertain and evaluate the present and potential impact of two specific water quality improvement projects on individuals, participating groups of recreationists, organizations, and communities;
2. Recommend substantive and procedural program changes to local lake districts, University of Wisconsin-Extention, Wisconsin Department of Natural Resources, and E.P.A.; and
3. Contribute to the development of a general method for social and economic evaluation of water quality improvement projects.

Each objective was achieved with varying degrees of success. The conclusions and recommendations drawn from this research effort are presented below.

Attitudes Toward Water Quality

Conclusion 1: Water quality is very important to Wisconsinites. Over 90 percent of residents in each study community and in a statewide sample reported that water quality was important to them. Two out of three Wisconsinites use lakes each year. Most Wisconsinites do not perceive water pollution as a "very serious" problem.

Recommendation 1: Protection of high quality lakes should receive high priority. Apparently most Wisconsinites perceive that their lakes are still of high quality. Unfortunately most lake management occurs only after a weed or algae crisis. While preventative maintenance is cheaper in the long run, neither individuals nor organizations are easily motivated without a crisis. Public policies should at least encourage long range planning.

Social Benefits for Individuals

Knowledge of Lake Ecosystems

Conclusion 2: White Clay Lake residents increased their understanding of the lake and the watershed as a result of involvement in the project. They recognized the importance of wetlands in protecting the lake and the role of nutrients from farm runoff in eutrophication. Waupaca residents, who had little involvement in their project, scored much lower and showed no better understanding of lakes than the statewide control sample.

Recommendation 2: Lake management programs should encourage public involvement and capitalize on the "teachable moment" that most large projects provide. Citizens, who understand the basic principle of ecosystems and the management options available, provide the core of political support for wise management of natural resources at the local, state and federal levels. Educational efforts not only facilitate the immediate decisions related to the project, but keep paying dividents in a democratic society.

Ascription of Responsibility

Conclusion 3: The federal government is not perceived to have primary responsibility for water quality. Respondents were equally split on whether primary responsibility resided with individual citizens, local government, or state government. White Clay Lake residents emphasized individuals while recreationists at both sites tended to emphasize a state role.

Recommendation 3: Federal agencies should not attempt to directly provide assistance in water quality management. Since the federal government is not recognized as having primary responsibility, federal assistance should flow through state and local channels.

Recommendation 4: "Personal ownership" of lake project elements should be encouraged. By ascribing responsibility to themselves and other individual citizens, White Clay Lake residents can be expected to act responsibly in other environmental matters. They are less likely to simply take the attitude that management of lakes or other natural resources are a "government problem".

Citizen Participation

Conclusion 4: White Clay Lake residents were strongly involved in their project; whereas in Waupaca, the elected and appointed public officials efficiently executed the project. In an unincorporated area, White Clay Lake residents built a new government structure. Everyone knew about it, and half had attended meetings. In the urban setting, the city council and city employees carried out their responsibility under representative government with only minor involvement of citizens.

Recommendation 5: Public participation should be facilitated by program structure but mandated efforts should be imposed with caution. The circumstances at White Clay Lake provided a textbook example of citizen participation. However, there was little need for such involvement at Waupaca--representative government was working. Annual meetings as required by Wisconsin law were not very meaningful; the city council made the decisions they were elected to make.

Improved Organizational Skills/Leadership Development

Conclusion 5: The White Clay Lake project provided training in self-governance. Three-fourths of the residents indicated that the experience had benefitted them personally. The lake district chairman went on to become a town board member.

Recommendation 6: Water quality management programs should promote both clean water and democratic ideals. Institutional arrangements that provide local input and train citizens for leadership may not be as efficient in the short run. But in the long run, these investments are essential for a democratic society which needs citizens with the knowledge, skills, confidence and willingness to become public officials.

Social Benefits for the Community

Conclusion 6: The lake projects improved the capacity of both communities to deal with other issues. Residents either felt the community was better able to cope with outside agencies or they didn't feel the projects had changed the community's ability to deal with other topics. They did not feel the projects had hurt the community in this regard.

Conclusion 7: The project enhanced community spirit at White Clay Lake. The project was the first focal point to bring the community together. Most residents seemed pleased by the attention the project focused on their little corner of a rural township. The project had little negative or positive impact on community cohesion in Waupaca.

Conclusion 8. The projects helped maintain the desirability of both communities as a place to live. While better than one-third of the residents said the projects improved the quality of life, only one person felt the community was less desirable. Most residents perceived the project as part of community maintenance rather than rehabilitation.

Recommendation 7. Public programs should be designed to strengthen local community abilities and attitudes. Projects should bring a community together for a common purpose rather than tear it apart. While controversy is a necessary part of public policy debate, agency policies can also determine how many wounds are opened with arrogance or healed with respect. If a project enhances the physical character of a lake, but rides roughshod over local pride, sensitivity, and initiative, it fails. If a project is unable to produce immediate physical results, but citizens gain an appreciation of the ecological and political complexity and feel good about the appropriate role played by state and federal agencies, it has still succeeded.

Impacts on Public Agencies

Conclusion 9: The water quality protection role of the U.S. Environmental Protection Agency was strongly recognized at White Clay Lake and poorly recognized at Waupaca. This appears to again be the result of citizen participation at White Clay Lake and lack of it at Waupaca. The Wisconsin Department of Natural Resources (DNR) is recognized most frequently as a water quality agency. The University-Extension and U.S. Soil Conservation Service (SCS) were highly visible at White Clay Lake.

Conclusion 10: In general, respondents in the study community felt agencies were doing a good and were more likely to give positive evaluations than the statewide control sample. The highest evaluations were awarded to the University of Wisconsin-Extension and U.S. Soil Conservation Service agencies that provided educational and technical advice but not financial assistance.

Recommendation 8: Public agencies should view the effort spent on education, community development, and technical assistance as an investment in both local infrastructure and broad public support for the agency. A centralized program has advantages of efficiency and uniformity. A program which uses local officials as a mechanism for administering projects is somewhat less efficient and may exhibit local values. But even local officials do not constitute broad public support for an agency's program. To achieve such support, education and involvement must extend beyond elected officials.

Social Costs

Conclusion 11: Neither project appeared to have a significant social cost to the residents of their respective community. The project caused no displacement of the labor force, changes in residential patterns, or diminution of services.

Economic Evaluation

Model Specifications

Conclusion 12: Ex ante evaluation techniques are available for performing economic aanalyses of lake rehabilitation and stabilization projects. Economic impacts can be estimated using a property value impact model, a recreation demand model and a linear programming farm simulation model.

Recommendation 9: Ex ante evaluation should be employed when possible to insure efficient projects and to allow for comparisons between projects competing for limited agency funds. With the increasing number of potential projects competing for scarce public resources it is imperative that these funds be allocated in the most efficient manner. This can only be accomplished through pre-project evaluation efforts.

Property Value Impacts

Conclusion 13: Benefits as reflected by property value changes at Waupaca exceeded projects by a ratio of at least 1.8 Assuming a discount rate of 7 1/8%, benefits exceeded $1,000,000. With a discount rate of 15% benefits exceeded $800,000. The project costs in constant 1977 dollars, were about $450,000.

Conclusion 14: Benefits associated with urban lake improvement projects are unequally distributed as property value benefits diminish with distance from the resource. Taxes that do not recognize this create an inequity whereby costs levied are not commensurate with benefits received.

Recommendation 10: The distribution of local cost shares should reflect the distribution of project benefits. Mill levied property taxes may not reflect the differential in benefit accumulations, due to lake improvement, to properties closer to the resources. If these normal assessment procedures do not adequately provide equity in the distribution of costs, a special assessment procedure may be necessary.

Recreation Benefits

Conclusion 15: Due to the high use rate of the Waupaca lake resources the recreation benefits are correspondingly large and help insure that benefits exceed costs, thereby making this project selection an easy choice. At White Clay Lake the use rate is low and consequently project benefits were exceeded by costs. However, with a modest assumption of a 3 percent annual increase the usage benefits will equal costs.

Recommendation 11: When performing an *ex ante* *evaluation, a project should not necessarily be dismissed when costs exceed benefits without first considering issues such as choice of discount, growth rates, option values, existence values, etc. If reasonable assumptions regarding these issues are needed, e.g., use of a 10 percent discount rate instead of 15 percent, then decision-makers may want to further consider projects that initially appear unjustified.*

Farm Impacts

Conclusion 16: Farmers at White Clay Lake increased their profitability as a result of installing manure storage facilities as part of the project. The subsidy rate of 90% received from state (40%) and federal (50%) sources were clearly beneficial to the farmers since their benefits greatly exceeded their 10% investment.

Recommendation 12: Cost-share rates should take into account the benefits (costs) experienced by project participators. At White Clay Lake government subsidies could have been reduced to about 40% and adoption of practices would still have been profitable for the farmer. Reduction of this sort would provide financial resources for additional pollution abatement efforts or reduce overall program costs. Although it may be unwieldy on a farm-by-farm basis, determination of the proper subsidy rates might be established by class (size) and location.

Recommendation 13: Change is difficult to obtain, particularly when it includes higher cost shares from the participator. To ease acceptance, an educational program should be considered to inform farmers of the advantages and/or disadvantages of BMP adoption, and of the available financial incentives.

Local Organizational Structure

Enabling Authority/Function

Conclusion 17: Special purpose units of government (lake districts) are necessary if general purpose units fail to manage lakes and the lakes are too small and numerous to be managed by state or federal agencies.

Recommendation 14: If state enabling legislation provides for creation of special purpose lake districts, the authority provided should match the responsibilities given to the districts. The major questions are likely to evolve around taxing authority and police power. Without these authorities, the role of the district will be limited financially or legally. However, granting the authority may lead to conflict with general purpose units of government. Other issues are likely to involve purchase or condemnation of land and relationship with the state water quality agency.

Boundaries/Creation

Conclusion 18: Boundaries which include the entire watershed may not be politically feasible. While ideal from a physical management point of view, landowners in the entire watershed may not identify with the lake. Including them could spell political trouble.

Recommendation 15: In attempting to identify a community-of-interest around a lake to form a boundary, consideration should be given to the source of the problem, who will benefit, and political reality. It is recommended to split an incorporated municipality. All riparian property and non-riparian land whose use is lake-oriented should be included.

Governance/Decision-Making

Conclusion 19: Lake districts function better when both permanent and seasonal residents share in decision-making. The constitutionality of voting by seasonal residents must be determined in the context of each state. Where permissible, the sharing of power tends to erode some of the normal hostility between "lake people" and "the locals".

Recommendation 16: States considering enabling legislation for lake districts should attempt to devise an institution that allows participation by full time residents and seasonal cottage owners. The taxation without representation is already poignant in lake communities. To create another taxing unit, and one of special interest to lake property owners, without giving them a role, would tend to further alienate them.

Recommendation 17: Special purpose districts should be independent but should be tied back to general purpose units of government. Unless such a provision is made, communication may not exist, duplication, and even competition could result. One method of providing a tie is to give general purpose units a seat on the commission of the special purpose unit.

Local Finances/Internal Equity

Conclusion 20: Local units involved in lake management need a variety of taxing authorities to meet financial needs with equity. Since both the benefits received and types of taxable property may vary across a unit, a single tax instrument may work an injustice on some taxpayers especially farmers with large holdings.

Recommendation 18: Institutional arrangements for special purpose units of government should provide the same taxing authority as general purpose units with some constraints on amount of tax. Special districts need revenue for year to year operation which can be most easily collected as a mill levy. They need small amounts that they can collect on a formula basis based on benefit received--user charge. And they need installment payment of special assessments for large projects.

Leadership/Motivation

Conclusion 21: Apathy is rational. If the group is large, an individual cannot see that his or her involvement will make any difference. If the lake can be enjoyed by those who didn't help with a project, as well as those who did, then a rational person will not spend his or her time and money.

Recommendation 19: Leaders should be provided with selective incentives. Various kinds of recognition can be awarded to those who sacrificed for the common good. Unless a community recognizes those contributions, motivation for leadership will simply fade away or illegal financial rewards will substitute for civic recognition.

Recommendation 20: Local communities should consciously attempt to elect at least one leader who vigirously pushes toward project goals and at least one leader to specialize in maintaining group morale. Without a mover-and-a-shaker, the group might have a good time but accomplish nothing of substance. With only zealots concentrating on the goal, the organization will disintegrate for lack of social glue.

Educational Assistance

Conclusion 22: Local property owners can take on responsibility for managing a lake if they receive educational support. Local property owners have the interest, but usually do not fully understand the lake system what can be done to manage it, and who can tackle the various management elements.

Recommendation 21: Educational assistance to local communities should be an institutionalized part of any state/federal program which relies on involvement by communities. In a democracy, any public program should have an educational component. That component is especially vital if local human resources are integrated into the institutional arrangement.

Technical Assistance

Conclusion 23: A centralized agency office can provide more consistent advice and better share/interpret technical experiences between communities than numerous private consultants. Private contractors have an obvious role in project implementation. Data collection for studies can be done either by agency personnel or by private consultants. Construction work is typically done by private contractors.

Recommendation 22: States should provide technical assistance and do so on a request basis.

Financial Assistance

Conclusion 24: Water users (recreationists and lake property owners) are not perceived to have the major responsibility to pay for water clean up. Water, at least in Wisconsin, is a free public good. Polluters, state government, and local government are expected to bear the cost of clean-up.

Recommendation 23: A priority system rather than a diminished cost-share should be applied when requests exceed funds available. Financial feasibility is ultimately determined by the willingness and ability of local communities to come up with their cost share. Diminishing the cost-share rate will penalize poorer communities.

CHAPTER 2

INTRODUCTION

Clean Water! The declaration from Congress was clear. The nation's waterways had deteriorated. In the first surge of the environmental movement, water pollution was attacked wherever found.

Public Law 92-500 set a national goal of fishable and swimmable water by 1983, authorized major funding, and established a series of subprograms to be administered by the Environmental Protection Agency (EPA). One of the subprograms, Section 314, became known as the Clean Lakes Act.

In 1976, the first grants were made to local communities to restore and protect their lakes. The communities planned to use various restoration techniques. However, no one within or outside the Environmental Protection Agency could certify that the best technique was being used for the situation, or that the most worthy projects were being funded.

Recognizing that the science of lake restoration was in its infancy, EPA decided to use 10 percent of Section 314 appropriation for evaluation of several early projects. Evaluations were designed to ascertain impacts on the lake ecosystem and the surrounding human community. On a few lakes, limnological and socio-economic analyses were undertaken. Mirror and Shadow Lakes in the City of Waupaca, Wisconsin, and White Clay Lake in Shawano County, Wisconsin, were the subject of such evaluations.

In the City of Waupaca, Mirror and Shadow Lakes were deteriorating as the result of nutrients that emptied into the lakes from storm sewers. At White Clay Lake nutrient inflow came primarily from farmland and barnyards in the agricultural watershed.

The Case Studies

Waupaca is a city of 5,000 people in central Wisconsin. Mirror Lake, 5.3 hectare (ha) in size, was experiencing algae problems and winter-kill of fish. Shadow Lake, 17.4 ha in size, had acceptable water quality, but citizens were worried about the drainage of Mirror Lake water into Shadow Lake.

The excess nutrients entering Mirror and Shadow Lakes were the result of two storm sewers. To deal with the nutrient-rich storm water, the lake district pursued a three-phased project: (1) eliminate most of the annual phosphorus (plant nutrient) loading by diverting the storm sewers from the lake; (2) treat the lakes with alum to precipitate the phosphorus in the water column and seal off the phosphorus-rich sediment; and (3) aerate Mirror Lake to promote turnover. The project cost about $450,000.

White Clay Lake is a 100 ha lake surrounded by dairy farms, a small resort, and a scattering of homes. Agriculture dominates the watershed and controls lake destiny.

Water quality in White Clay Lake had always been high, but previous studies indicated that this quality was endangered. Nutrient runoff from watershed barnyards and erosion from cultivated fields threatened the lake. To protect the lake, a lake district was organized by local landowners. The lake stabilization objective of the district was to reduce the amount of phosphorus reaching the lake by implementing various watershed controls. These included manure storage facilities, upgrading barnyards, water diversions, and other watershed improvements. The controls cost about $250,000.

The expected outcomes of the interventions were specific to the lakes in question. At White Clay Lake the interventions were designed to protect the lake from future water quality decline. At Mirror Lake the intervention was expected to rehabilitate the lake to a level of higher water quality. The Shadow Lake project was designed to protect the lake from further deterioration and reverse some of the early signs of eutrophication.

Study Design

The research objectives were stated in Chapter 1. In order to obtain these objectives it was necessary to make some modifications as this study began after the technical intervention was well along. Therefore, it was not possible to employ a classic experimental design. We could not directly measure behavior or attitudes before the project began and compare them with behavior or attitudes after the project.

In order to develop a quasi-experimental design, we assumed that before the projects were implemented, the study communities were similar to the state as a whole. We then assumed that any difference between the study communities and the statewide sample was due to the projects.

There may have been some maturation effects, e.g., all state citizens may have become more conscious of water quality during the years the project was in progress at the study communities. Our research design did not permit us to segregate such maturation effects.

We did ask respondents to recall their behavior and attitudes. We are aware of the potential problems with recall and discuss the implications later in the report. However, this method allowed us to infer changes brought about by the project as perceived by the people in the communities.

By consulting with appropriate specialists, we were also able to estimate the possible water quality in the study lakes with the projects. I was also critical to show what would have happened to the lakes if management effort had not curred, as changes would occur in the absence of the projects. Such information was necessary for a with and without economic analysis.

In the chapters to follow a profile of both lake communities will be provided as well as a description of their respective projects. In Chapter 5 a discussion of the survey method is presented. Chapter 6 provides survey results with regards to attitudes towards water quality. Social impacts associated with the project are presented in Chapter 7. Chapters 8, 9, and 10 describe the economic evaluation by first presenting the models to be used in the evaluation and then the results pertaining to the Waupaca and White Clay Lake projects, respectively. The last chapter is a discussion of lake management organizational structure at the local and state level. Conclusions and associated recommendations have been presented in Chapter 1.

CHAPTER 3

WAUPACA PROFILE AND PROJECT

Mirror and Shadow Lakes are located in the City of Waupaca, the county seat of Waupaca in east central Wisconsin. As is the case for the county, the City of Waupaca has experienced a higher growth rate than the state if Wisconsin and the national metropolitan area averages (59). This is a relative small town whose population has grown steadily since 1960 from 3,934 to 4,586 in 1977, an approximately 17 percent increase over that 17-year period.

The economic base of the city of Waupaca has an unusually large percentage of manufacturing durables employment for such a small, rural town. More than 900 persons, 25 percent of city employment, are employed in jobs within this category, primarily in the Waupaca Foundry. Retail trade employs over 650 workers in the city, which represents 19 percent of city employment. Local government employees represent 16 percent of city employment, and manufacturing non-durables, which employs over 300 people in cheese processing, potato chip manufacturing, and knitting mill, represents 10 percent of total city employment. Services employ more than 600 people (18 percent of city employment) primarily in retirement homes and tourist facilities. This is higher than the corresponding county, state or even United States employment percentage (58).

Since 1970 manufacturing employment has declined. Furthermore, while agriculture continues to play a significant role in the economic base of the county, the trend of declining farm acreage and farm employment continues (59). The only growth sector for the local economy of Waupaca has been in services (59). The recent growth in service jobs is due primarily to the increased number of retirement homes, summer cottages, and substantial tourist activity within the county.

South Park--Mirror and Shadow Lake

Mirror and Shadow Lakes are both found within the corporate limits of the city. Mirror Lake has limited public access, is small, and drains directly into Shadow Lake.

Shadow Lake has had extensive public use for centuries. Menominee Indians regularly camped there and continued to camp there for years after the arrival of white settlers. Indian flints are still found around the lake.

In 1906, a group of women started a campaign to make Wright's Grove on Shadow Lake a park, but it wasn't until 1921 that the city council voted to acquire the property. A restrictive clause in the deed specifies that the property must be used by the city for park purposes only.

The recreation program for the city was started in the summer of 1946 with many activities taking place at South Park. In 1947 a complete Red Cross swimming instruction program was begun. In 1956 the Waupaca firemen built the concrete bath house for the park. In 1958 the parking lots, picnic tables, flower gardens and playground equipment were added. Attendance has fluctuated over the years between an estimated 40,000 and 75,000 recreators per year. [1/], [2/]

However, as early as 1962 weeds began to appear in the swimming area on Shadow Lake. The water quality was still good but warnings of deterioration had begun to appear. The following is a chronology of the efforts that transpired and eventually resulted in the lake rehabilitation project to deal with this problem.

Project Chronology

1968-1969	Property owners on Mirror Lake, which was suffering from algae blooms and winter kills, asked the State to study both lakes and provide appropriate treatment.
1970	State and city officials discussed the matter.
1971	The city council formally passed a resolution requesting the Inland Lake Demonstration Project undertake a study and make recommendations. The study was paid for by the Upper Great Lakes Regional Commission and was conducted by the Wisconsin DNR and the University of Wisconsin Extension. The study concluded that 50 percent of the nutrient (phosphorus) inflow to the lakes was attributable to the storm sewers entering the lake. Storm sewer diversion and aeration of Mirror Lake was recommended.
1972-1973	An experimental hypolimentic aerator, for mixing the cold bottom waters with better quality surface water, was installed. The experiment was not successful.
1974	Shortly after the Wisconsin Legislature passed a new statute (Chapter 33) to permit local communities to undertake lake management, the city council created "The City of Waupaca Inland Lake Protection and Rehabilitation District".
January 1975	The new district applied for technical assistance requesting a design for a feasibility study. The need for a study was waived because of the previous research.
May 1975	The district submitted a proposed rehabilitation plan to DNR. Later that month public hearings were held on the plan.
Summer 1975	The district, through DNR, requested an Environmental Protection Agency (EPA) grant for construction work in rerouting storm sewers.
November 1975	The members of the lake district voted to tax themselves to pay the local share of the project cost.
January 1976	EPA committed funds to the project. Contracts were led by mid year. Cost shares amounted to:

EPA	50%	$215,000
DNR	30%	130,000
District	20%	85,000
TOTAL	100%	$430,000

July 1976	Construction began on diverting the storm sewers. The press and media covered the progress of the construction. The diversions were completed early in 1977.

1977	Aluminum sulfate was added to Mirror Lake to precipitate phosphorus in the water and seal off the nutrient rich sediment.
1977-1981	DNR and University of Wisconsin Extension evaluated the limniological, social and economic impacts of the project.

Lake Rehabilitation Project

As indicated above, previous studies had revealed that the primary source of nutrient (phosphorus) inflow was from storm sewer drainage directly into Mirror and Shadow Lakes. As a result the eutrophication process was hastened and a decline in water quality resulted. The eutrophication problem confronting the Waupaca lakes required several remedial steps. These consisted of storm water diversion, in-lake alum treatment, and aeration of Mirror Lake.

Storm Sewer Diversion

Prior to 1977 storm sewer drainage discharged directly into Mirror and Shadow Lakes. Mirror Lake received effluent from two separate storm sewers, and Shadow Lake from a stream into which storm sewer drainage entered. Approximately 60 percent of the watershed is urban with the resulting stormwater runoff conducted directly to the lakes.

The two storm drainage basins around Mirror Lake cover an area of 19.9 ha, primarily a residential area. These two basins had little interference from groundwater and exhibited characteristics of urban runoff.

The storm drainage basin entering Shadow Lake incorporated about 20.2 ha of developed urban land north and east of the lake and about 36.4 ha of undeveloped lowlands surrounding an intermittent stream which flowed into Shadow Lake.

In 1972 and the first five months of 1973, storm sewer runoff was measured. The storm sewer inputs for various chemical parameters resulting from this runoff are presented in Table 3.1.

Table 3.1--Total Storm Sewer Input for 1972

	Mirror Lake	Shadow Lake
	---kg---	
Total Phosphorus	9.8	14.4
Reactive Phosphorus (est.)	3.3	4.8
Total Nitrogen	57	6,146
Inorganic Nitrogen	28	62
Organic Nitrogen	29	84
Biological Oxygen Demand	269	340
Chloride	1,602	14,243
Sodium	775	6,714
Potassium	85	268
Calcium	290	3,447
Magnesium	149	1,724
Total Solids	7,648	28,576

Source: J. O. Peterson, unpublished data.

A larger amount of material entered via the Shadow Lake storm sewer, but this was a result of the larger area of the drainage basin. However, runoff coefficients were less for Shadow Lake than Mirror Lake because that part of the drainage basin for the Shadow Lake storm sewer was undeveloped land. As an example, the total phosphorus runoff coefficients were 0.5 kg/ha/yr. and 0.3 kg/ha/yr. for Mirror and Shadow Lakes, respectively.

The nutrients entering the lakes via the storm sewers were potentially more detrimental to Mirror Lake than Shadow Lake. Vollenweider's permissible and dangerous phosphorus loading rates for lakes of this mean depth are $0.088 g/m^2/yr.$ and $0.172 g/m^2/yr.$, respectively (61). The phosphorus loading rates from the storm sewers alone were $0.192 g/m^2/yr$ for Mirror Lake which exceeds Vollenweider's dangerous loading rate. The loading rate for Shadow Lake's storm sewer was $0.085 g/m^2/yr$, which approximately equals the permissible loading rate.

During 1976, all storm sewers entering Mirror and Shadow Lakes were diverted away from the lakes and into the Waupaca River. Studies have determined that the storm water diversion had insignificant impact on the Waupaca River.

A clear beneficial impact of the project is the improvement of water quality in Mirror and Shadow Lakes. The expected changes will have long-term beneficial effects on the water quality of the two lakes. Using the phosphorus residence model of Sonzogni, Uttormark and Lee, the new equilibrium in total phosphorus for Mirror Lake would be established in approximately eight years (49). The reduction in concentration was projected to drop from a mean annual concentration of 8/μg/l to 17μg/l. The addition of alum hastened the recovery and a new equilibrium was established at 23 μg/l within one year. If no action had been taken, the lakes would have been expected to further diminish as a recreational asset to the community.

Diverting storm sewers had the immediate effect of reducing the watershed size of both lakes. Mirror Lake's watershed was reduced by 59 percent to 13.1 ha. and the drainage basin for Shadow Lake was reduced to 56.7 ha., a reduction of 26 percent.

More important than watershed size reduction was the change in drainage area characteristics of the remaining drainage basin. Before the storm sewer diversion, 10 percent of Mirror Lake's watershed were streets and parking lots, while presently there are only two short streets in the basin. The number of roof tops has also been greatly reduced. At the present time, the drainage basin consists of residential lawns between the lake and the closest streets and city park land.

The percentage of street and parking lot area was smaller for Shadow Lake -- at six percent. Following storm sewer diversion, a parking lot at the city park remains in the watershed, and one street travels along part of one side of the lake shore, but most of the drainage basin is residential lawns, a cemetery, and a city park. The ratio of watershed area to lake surface area since the storm sewer diversion is 2.6 and 3.3 for Mirror and Shadow Lakes, respectively.

Changes in phosphorus and nitrogen loading rates prior to and following storm sewer diversion in Mirror Lake are noted in Table 3.2 Phosphorus loading rates were reduced 65 percent but nitrogen rates were reduced only 25 percent. Phosphorus loading rates in Mirror Lake presently are greater than Vollenwider's permissible rates, but are now below his dangerous levels (61).

Mirror and Shadow Lakes did not show any dramatic change in 1977, the first year following storm sewer diversion. This was not unexpected since a great deal of phosphorus was derived from the bottom sediments during periods when the bottom waters were anaerobic. It has been reported that diversion of a major nutrient source can improve the water quality of a lake (53). However, improvements are not always immediate. Lake Sammamish, located in King County, Washington, showed little sign of recovery for seven years following a one-third reduction in phosphorus loading, largely as a result of high phosphorus release rates during anaerobic conditions in bottom waters, but the lake later showed signs of recovery (65). It takes many years for lake problems to develop. It also takes many years for protection and rehabilitation actions to manifest themselves in clear lake improvements.

Table 3.2--Phosphorus and Nitrogen Loading Rates for Mirror Lake (g/m^2/yr.)

Phosphorus

	1972	1973	1977	1978
Storm sewer	0.190	0.261	0	0
Groundwater	0.002	0.002	0.002	0.002
Diffuse runoff	0.060	0.097	0.046	0.069
Precipitation	0.053	0.016	0.055	0.061
Total	0.305	0.376	0.103	0.132

Nitrogen

	1972	1977	1978
Storm sewer	0.968	0	0
Groundwater	1.184	1.184	1.184
Diffuse Runoff	0.586	0.445	0.677
Precipitation	0.868	1.139	1.000
Total	3.607	2.768	2.861

Source: J. O. Peterson, unpublished data.

Following storm sewer diversion from Mirror and Shadow Lakes in December, 1976, external phosphorus loading rates were reduced 65 percent and nitrogen was reduced 25 percent in Mirror Lake.

Mirror Lake exhibited little change following storm sewer diversion in 1976 in regard to water chemistry or water transparency. However, blue-green algae which were observed following rain storms in years prior to 1977 were not observed in 1977.

Alum Trueatment

Aluminum sulfate can be applied to lakes to precipitate phosphorus from the water column. The practice was first done in Scandinavia in the 1960's, with the first North American application being in Wisconsin Horseshoe Lake (44). Since then it has been used with varied success throughout the country.

The principle behind alum treatment is that the aluminum hydroxide combines with dissolved inorganic phosphorus to form a precipitation. The resulting floc settles to the lake bottom (12). A small amount of particulate phosphorus is also physically entrapped by the settling precipitate and carried with it to the bottom. Once on the bottom the alum layer acts as a seal preventing the migration of phosphorus from bottom sediments to the overlying waters.

An earlier study noted that during anaerobic conditions phosphorus concentrations became elevated in the bottom waters as a result of sediment release (44). Therefore, alum was applied to Mirror and Shadow Lakes not so much to remove phosphorus from the water column, but to prevent sediment release during anaerobic conditions.

Since the principal objective of alum treatment is sealing off the bottom sediments, only the area below the epilimnion was treated. The alum was injected at a depth of three meters, the bottom of the epilimnion. Alum has proven to be ineffective in sealing sediments in the mixing zone, i.e., epilimnion, therefore, in order to minimize costs only the area below the epilimnion was treated.

Prior to the application a three-meter contour was delineated and the lakes were divided into sections with buoys. Based on water volume in each section, the number of barge loads was calculated to achieve the appropriate alum concentration.

Mirror Lake received 40,900 kg of alum (1,718 kg Al) and Shadow Lake was treated with 81,000 kg of alum (3,400 kg Al) injected at the 3-meter level in both lakes. Assuming an even distribution of alum below this depth, the average aluminum concentration was 6.6 µg/l and 5.7 µg/l in Mirror and Shadow Lakes, respectively. Sedimentation traps in the bottom of Mirror Lake indicated that it took longer than 24 hours for all of the alum to reach the lake bottom.

Although the phosphorus level was higher in Mirror Lake than in Shadow Lake, the post treatment concentration was the same, about 20 µg/l. This concentration has been maintained through November 1979 in both lakes. The average annual phosphorus concentration in Mirror Lake prior to the alum treatment ranged from 88 µg/l to 93 µg/l, but following treatment the annual mean was 20 µg/l, a reduction of 78 percent. The reduction is not as dramatic in Shadow Lake because the initial phosphorus concentrations were lower. Pretreatment concentration was 55 µg/l and post-treatment concentration was 23 µg/l, a reduction of 58 percent.

The reduction of dissolved reactive phosphorus (DRP) was even greater. The average concentration in Mirror and Shadow Lakes was 36 μg/l and 17 μg/l, respectively. In both lakes following ice-out in 1978 DRP was low (5 μg/l), especially in Mirror Lake and to a lesser extent in Shadow Lake this was a result of biological uptake as total phosphorus did not decline as much as DRP. Since the alum treatment, the average DRP concentration has been less than the detection limit of 4 μg/l. It is only in late summer in Mirror Lake that DRP has been detected in the lake.

A side effect of alum treatment is lowered alkalinity of pH. The alum application reduced the alkalinity and pH only near the level of the manifold outlet (3 m). The lowest alkalinity and pH observed was 159 μg/l and 6.8, and 105 μg/l and 6.5 in Mirror and Shadow Lakes, respectively. These levels were not low enough to cause problems.

Sediment cores were taken along a transect in both lakes before (1977) and after (1979) the alum treatment to determine the aluminum distribution. The cores were unsuccessful in determining the aluminum distribution. In most instances aluminum concentrations were higher in 1977 than in 1979. Often the maximum aluminum concentration was in the top core slice both in the pretreatment and posttreatment core. Aluminum concentrations were higher in the deeper waters, but this would be expected without the alum treatment since aluminum is usually associated with finer particles which tend to settle in the deeper waters (8).

The applied aluminum failed to show up in the cores because the addition was small compared to the background concentrations. Since background levels are high it would not be expected that alum treatments in these and similar lakes would be detrimental to benthic invertebrates.

The anticipated costs for aluminum sulfate treatment were $21,000. The actual cost for alum treatment totalled $8,771, and was itemized as follows: chemical cost equalled $6,207 and application cost equalled $2,564.

In sum, the alum treatment reduced total phosphorus from an annual mean of 90 μg/l to 20 μg/l in Mirror Lake and in Shadow Lake from 55 μg/l to 23 μg/l. The maximum phosphorus concentrations in the bottom water have been reduced an order of magnitude. The DRP concentrations have continuously been below 4 μg/l since alum treatment.

Following alum treatment, nitrogen levels have not changed significantly. Ammonium-N concentrations in excess of 3 μg/l are still observed in bottom waters. The one significant change was the increased concentrations of inorganic nitrogen (primarily in the form of NO_3-N) in the spring of 1979.

Water transparency increased in both lakes following alum treatment, but reverted back to pretreatment levels and actually decreased in Mirror Lake in the summer of 1979. This decreased transparency seemed to be a result of increased background attenuation of light and not increased algal biomass.

Aluminum sulfate treatments are effective in phosphorus control by sealing bottom sediments thus preventing phosphorus migration during anaerobic conditions. This treatment should only be considered in well stratified lakes. It seems necessary, however, to reduce the external phosphorus sources to an acceptable level prior to an alum treatment, otherwise benefits derived as a result of treatment probably will be short-lived.

Aeration (Artificial Circulation)

Studies in 1972-1973 determined that Mirror Lake was probably meriomictic (it did not mix) resulting in a permanent anoxic environment in the bottom waters (50). In order to replenish the oxygen the lake is being artificially circulated before ice formation in the fall and following ice-out in the spring.

Artificial circulation is one of the most efficient lake aeration techniques. Aeration is a common method of alleviating the problem of dissolved oxygen depletion and has a long history of use in lakes and reservoirs. Although it is generally viewed as a cosmetic treatment of the symptons of eutrophication, it also has the potential for improving the nutrient status of lakes and retarding or reversing the process of eutrophication. The objective of most aeration projects, however, is limited to improve dissolved oxygen conditions for the fishery.

In Mirror Lake, total circulation was undertaken to increase the dissolved oxygen content of the bottom waters by mixing the entire lake water volume.

The aeration unit at Mirror Lake consists of a compressor on the lake shore and 2-inch plastic pipe from the compressor to the deep area of the lake. The pipe was laid along the lake bottom and weighted with cement blocks. The end of the pipe in the lake has three 3/8-inch holes spaced about nine inches apart. The compressed air itself does not aerate the water. The unit only mixes the water column, and oxygen is distributed throughout the lake as a result of the mixing action with aeranated water near the surface. The compressor is usually run two to three weeks in the spring and again in the fall.

Because the compressor started late in the year 1977, some concern was expressed about creating an open-water hazard. At a time when the lakes in the area were developing a total ice cover, the compressor was creating a two-acre area of open water. Consequently, the compressor was turned off after three days. Within the three-day period, the lake was totally mixed; however, the introduction of oxygen-demanding substances from the anoxic water that was mixed into the overlying oxic waters caused an initial dissolved oxygen depression throughout the entire lake. At the time the compressor was shut off, the weighted average dissolved oxygen for Mirror Lake was 2.6 µg/l. Although oxygen levels were low during ice cover (generally 1.0 µg/l), a fish kill was not recorded.

A consequence of spring mixing in Mirror Lake is the increased temperatures in the bottom waters on the onset of stratification in May. Before mixing, bottom water temperatures were generally about 6°C, but with mixing these temperatures increased to 10°C.

The result of artificially circulating the lake in the spring and fall is a substantial increase in the dissolved oxygen concentrations in Mirror Lake before ice cover and the prevention of winterkill conditions at a relatively low cost. The anticipated costs for artificial circulation was budgeted at $3,000. The actual cost for this portion of the project was $1,937.

Water Quality Indices

The preceeding discussion of the physical intervention at Mirror and Shadow Lakes and the associated impacts on the various water quality parameters indicates that a change has transpired. However, a change in water quality of a given water resource must be perceived by the individual decisionmaker to register an economic impact, e.g., a change in property value or a change in recreational activity. If an actual water quality change remains unnoticed, or if what is noticed is not valued no impacts will result. Perceived change may have little or no correspondence to factual changes. Likewise, what is technically important in water quality may bear little, if any, resemblance to what the public considers valuable. An index must be used to describe water quality in a fashion that the individual decisionmaker can relate to. Two such indexes, the Perceived Water Quality Index (PWQI) and the Lake Condition Index (LCI) are presented here and employed in the subsequent economic analysis.

Perceived Water Quality Index

The PWQI was developed by Dornbusch and Associates to provide a statistically significant explanatory variable in an economic model designed to estimate the impact of water quality changes on property values (10). In this effort a survey was conducted at representative sites throughout the U.S. to determine what the public considered to be indicators of water quality. The primary water quality aspects understood by lay people were found to be (1) industrial waste, (2) debris in or on the water, (3) clearness of the water, (4) algae in the water, (5) odor from the water, (6) wildlife support capacity of the water body, and (7) the recreational opportunities offered by the water body.

The relative importance of these seven aspects of water quality were determined by having the respondents weight them. The capacity to support wildlife and the recreational opportunity provided by the water resource were viewed as the most important aspects while the presence of algae was deemed the least offensive. The weights reported were .10, .05, .07, .04, .05, .43 and .26, respectively.

After identifying and weighting the relevant subjective water quality parameters, the respondents were then provided with five descriptions of water quality conditions for each of the seven water quality parameters. An example is presented here for recreation opportunity:

A. The water quality is good enough to permit swimming fishing and boating, as well as picnicking, walking relaxing or sunbathing along the water's banks.

B. The water quality is good enough to permit all of the activities mentioned above, except that you cannot swim in the water.

C. The water quality is good enough to permit all of the activities mentioned above, except that you cannot either fish or swim in it.

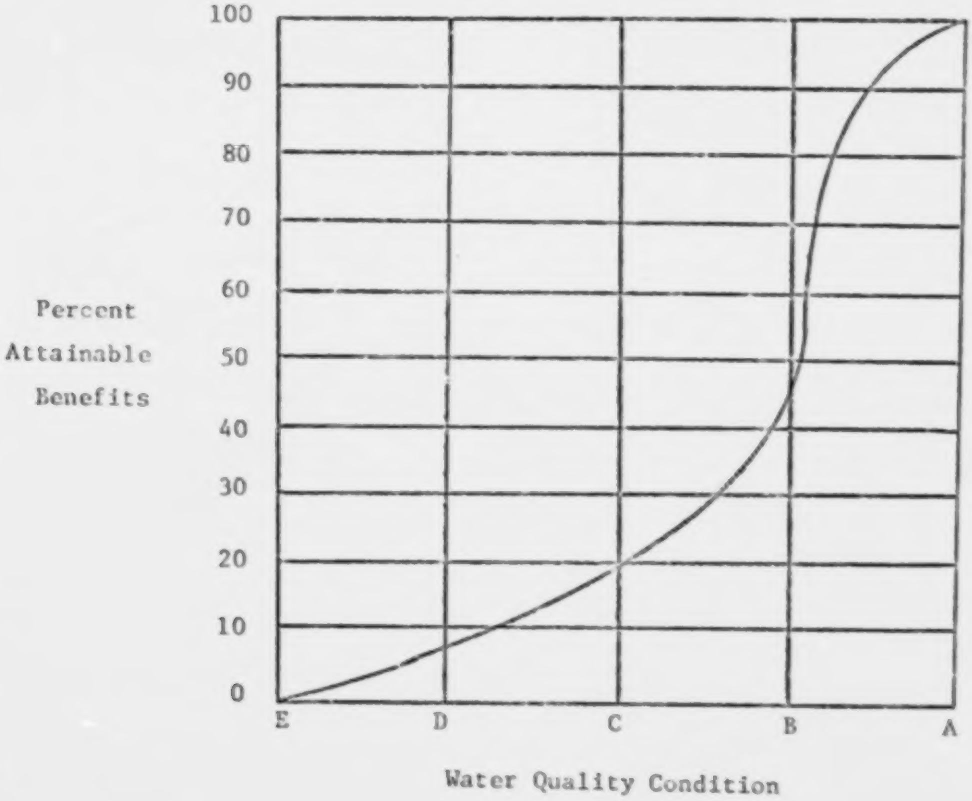
D. The water quality is only good enough to permit walking, picnicking, relaxing or sunbathing along the water's bank; you cannot boat, fish, or swim in it.

E. The poor water quality will permit no recreation activities in or near the water.

Next, respondents were requested to rate the degree of acceptability of each of these conditions on a scale of zero for totally unacceptable to twelve for totally acceptable. A standardized grid was developed to transform the vertical axis to "percent of attainable benefits". A curve was then fitted to the mean acceptability of each category for the parameter in question. An example is shown in Figure 3.1 for recreation opportunities. Here, as with the other measures of water quality, the curve exhibits an "S" shape which indicates that a certain threshold in water quality has to be reached before an improvement will yield benefits and that there exists a point beyond which further improvement yields diminishing returns in terms of residents' evaluation of change. Not only is this intuitively appealing, but such a phenomena has been substantiated in psychophysical experimentation, and is consistent with economic theory (10).

Figure 3.1-Percent Attainable Benefits for Recreation Opportunity

(Relative Weighting $a_7 = .26$)



Water Quality Condition	Description
A	The water quality is good enough to permit swimming, fishing and boating, as well as picnicking, walking, relaxing or sunbathing along the water's banks.
B	The water quality is good enough to permit all of the activities mentioned above, except that you cannot swim in the water.
C	The water quality is good enough to permit all of the activities mentioned above, except that you cannot either fish or swim in it.
D	The water quality is only good enough to permit walking, picnicking, relaxing or sunbathing along the water's banks; you cannot boat, fish, or swim in it.
E	The poor water quality will permit no recreation activities in or near the water.

Table 3.1--Percent Attainable Benefit Matrix
(B_{ijk}) for Recreation Opportunity

Relative Weighting $a_7 = 0.26$

To j / From i	E	D	C	B	A
E	0	7	20	45	100
D	-7	0	13	38	93
C	-20	-13	0	25	80
B	-45	-38	-25	0	55
A	-100	-93	-80	-55	0

Water Quality Condition	Description
A	The water quality is good enough to permit swimming, fishing and boating, as well as picnicking, walking, relaxing or sunbathing along the water's banks.
B	The water quality is good enough to permit all of the activities mentioned above, except that you cannot swim in the water.
C	The water quality is good enough to permit all of the activities mentioned above, except that you cannot either fish or swim in it.
D	The water quality is only good enough to permit walking, picnicking, relaxing or sunbathing along the water's banks; you cannot boat, fish, or swim in it.
E	The poor water quality will permit no recreation activities in or near the water.

For later use in the economic evaluation tables, based upon the each of attainable benefits "S" curve, were constructed for each of the water quality parameters. An example of such a matrix is presented in Table 3.1 for recreational opportunity.

These tables are used in the following manner: After a change in water quality has been achieved for a given resource, the consensus of the community with regards to the amoung of change for each of the seven categories would be ascertained through a survey. The amount of change would take the form of "from condition _____ to condition _____." The corresponding value would be extracted from the table and multiplied by the relative weighting for that category. This would be done for all seven categories, and the resulting values summed to give a value representing the Perceived Water Quality Index by residents. Mathematically this is presented by:

$$PWQI_{Res} = \sum_{k=1}^{7} a_k B_{ijk} \qquad (3.1)$$

where $PWQI_{Res}$ is the perceived water quality index of residents, a_k is the relative weighting of category k, and B_{ijk} is the value of attainable benefits reflecting the change from condition i to condition j for the k^{th} category.

For the purpose of project justification, however, such an ex post procedure is of little value. To allow for an ex ante project valuation it is necessary to predict the lay person's perception of water quality and water quality change. While water quality experts cannot tell a planner what the changes perceived by residents will be they can translate the technical water quality changes sought and expected through the project into the kinds of change deemed relevant to residents.

The task then is to predict the residents $PWQI_{Res}$ with the expert's *ex ante* $PWQI_{Exp}$. This relationship was estimated by Dornbusch using pooled, cross-section data from 17 sites across the U.S. based upon experts' responses to the same questions presented the lay person. The estimated relationship was found to be:

$$PWQI_{Res} = -24.778 + .463\ (PWQI_{Exp}) + 15.501\ (PA) - 7.056\ (River) \qquad (3.2)$$

$$\text{(t-statistic)}\quad (-3.107) \quad (3.546) \qquad (5.266) \quad (1.174)$$

$$R^2 = .741$$
$$d.f. = 13$$

where River is a dummy variable taking on the value of 1 when the water body in question is a river and zero otherwise; and where Public Access takes a value of 1, 2, or 3 depending upon the degree of public accessibility to the lake as based upon shoreline accessibility.

To estimate the stream of benefits over the life of the project annual estimates of the seven water quality parameters with and without the project are necessary. These estimates were provided by the DNR limnologist acting as the principal investigator in EPA Grant #804687-01: The Limnological Evaluation of the Lake Restoration Project at Mirror and Shadow Lakes. Estimates from the above study were provided with the following qualifications:

1. Accurate estimates can only be generated by computer simulation models, and even then such models can't take into full account the impact of unique and unforeseen lake characteristics. Since neither the time nor funding was available to do simulation work, the estimates provided represent only approximations by the limnologist based on his experience and expertise.

2. Since algae blooms on Mirror and Shadow Lakes are not considered "typical", the visible algae problems are based on a fall-winter-spring period only.

The with and without project estimates of the seven water quality parameters at their corresponding water quality index values over the life of the project are provided in Tables 3.3 and 3.4 for Mirror and Shadow Lakes, respectively.

For Mirror Lake the greatest improvements are realized in the algae and wildlife support parameters in the first four years with the project. Without the project the water clearness and recreational capacity parameters deteriorate after 30 years. For Shadow Lake the impact of the project is primarily to maintain present water quality of the lake. Only the algae and wildlife support capacity parameters show any improvement after four years with the project. Without the project, water clearness, algae, odor, wildlife support and recreational capacity parameters all deteriorate after 30 years, and this wildlife support parameters continues to deteriorate further in the last year considered in this project.

Lake Condition Index (LCI)

The LCI was developed in 1975 to classify all Wisconsin Lakes larger than 100 acres (60). This index is based on penalty points accumulated for four parameters: dissolved oxygen in the hypoliminion (0-6 penalty points); Secchi disk transparency (0-4 penalty points); fish winterkill (0-4 penalty points); and algae growth (0-9 penalty points). The penalty points range from 0-23. A lake with poor water quality would accumulate a large number of penalty points and would consequently have a high LCI value; and conversely, a lake with good water quality would have a low number of penalty points and a low LCI.

Table 3.3--Estimates of Water Quality Parameters for Mirror Lake

Water Quality Parameter	Initial Year	Year of Change				Final Year
	1976	1977	1978	1979	2001	2010
Industrial Waste						
With Project	A					A
Without Project	A					A
Debris						
With Project	A					A
Without Project	A					A
Clearness						
With Project	B				B	B
Without Project	B				C	C
Algae						
With Project	D	C	B	A		A
Without Project	D	D	D	D		D
Odor						
With Project	B			A		A
Without Project	B			B		B
Wildlife Support						
With Project	D	C	B	A		A
Without Project	D	D	D	D		D
Recreation Opportunity						
With Project	A				A	A
Without Project	A				B	B

Source: Wisconsin State Department of Natural Resources
(Doug Knauer, Limnologist)

Table 3.4--Estimates of Water Quality Parameters for Shadow Lake

Water Quality Parameter	Initial Year 1976	Year of Change 1979	2001	Final Year 2010
Industrial Waste				
With Project	A	—	—	A
Without Project	A	—	—	A
Debirs				
With Project	A	—	—	A
Without Project	A	—	—	A
Clearness				
With Project	B	—	B	B
Without Project	B	—	C	C
Algae				
With Project	C	B	B	B
Without Project	C	C	D	D
Odor				
With Project	A	—	A	A
Without Project	A	—	B	B
Wildlife Support				
With Project	B	A	A	A
Without Project	B	B	C	D
Recreation Opportunity				
With Project	A	—	A	A
Without Project	A	—	B	B

Source: Wisconsin State Department of Natural Resources
(Doug Knauer, Limnologist)

The LCI was estimated for Shadow Lake, again by the limnologist researching the water quality impacts, to allow comparison of the water quality, and throughout the project period for both the with and without project conditions. Since only property values and no recreation benefits will be calculated for Mirror Lake, the LCI for Mirror Lake is not presented.

LCI totals for Shadow Lake indicate continual improvement with the lake protection/rehabilitation project. As an example, the before the project LCI is 10. In 50 years without the lake project the LCI rating is forecasted to be 20. With the project, the 50-year projection is an LCI of 6. The years in which changes occur are presented in Table 3.5. It is assumed that after the last change in 2010 the water quality will stabilize for the duration of the analysis period.

Table 3.5--Shadow Lake LCI with and without project.

Year	LCI (With Project)	LCI (W/o Project)	LCI Difference
1977	10	10	0
1979	9	10	1
1980	8	10	2
1981	7	10	3
1982	6	10	4
1999	6	12	6
2000	6	14	8
2001	6	16	10
2002	6	18	12
2009	6	18.7	12.7
2010	6	20	14
2026	6	20	14

Source: Wisconsin State Department of Natural Resources. (Doug Knauer, Limnologist)

CHAPTER 4

WHITE CLAY LAKE PROFILE AND PROJECT

White Clay Lake is a 100 ha, natural lake in Shawano County in northeastern Wisconsin. The township had a 1980 population of 1200. Second homes and the recreation industry provided a major part of the local economy. Shawano Lake is the central recreational attraction of the county. White Clay Lake is primarily used for quiet fishing as an alternative to large, noisy motors on Shawano Lake. It is also used extensively for ice fishing.

Watershed Character

The lake is in a small watershed of 1200 ha that is dominated by agriculture. Sixty-six percent of the land is cropped. There are twenty livestock concentrations in the watershed and another five which potentially affect the watershed through manure spreading. Woodlands and wetlands, one small resort, a crossroads bar, a church, and a few non-farm residences comprise the rest of the watershed. Thus, most pollutants entering the lake probably originate from agricultural activities.

Agriculture in the White Clay Lake watershed is primarily dairying. The trend on these dairy farms has been towards larger herds concentrated in exercise yards and feedlots. Associated with this has been more land devoted to corn production and potentially more sediment and nutrient runoff and a hastening of the lake eutrophication process. Although White Clay Lake is considered to be of good quality, the phosphorus input to the lake is greater than the concentration level considered dangerous by Vollenweider (61) from the standpoint of eutrophication control (67).

Consequently, this valuable recreational resource became a candidate for lake protection efforts.

Project Chronology

1969 The White Clay Lake watershed was selected for study to measure the significance of agricultural pollution but funding was not available.

1971 Shawano County Agricultural Stabilization and Conservation Committee and the Soil Conservation Service began providing intensified assistance to watershed farmers. Special funds were set aside through the Rural Environmental Assistance Program (REAP). Three animal waste projects and one seeding project were cost shared with $8,727.

1972 Shawano County Soil and Water Conservation District supervisors accepted the White Clay Lake project as a Lumberjack Resource Conservation and Development project and requested a complete soil survey on the 1200 ha White Clay Lake watershed. REAP provided an additional $7,098 for three animal waste projects and one sediment retention and water control structure.

1973 Intensive monitoring by the University of Wisconsin Extension began in the White Clay Lake watershed. Funding was provided by the Upper Great Lakes Regional Commission. The study documented the movement of nutrients and sediment from agricultural land, barnyards, and animal rest areas into the lake.

1974 REAP provided $6,000 for another animal waste project and a waterway project.

1975 The White Clay Lake District was formed by the Town of Washington, Shawano County. The district submitted a technical assistance application to DNR. No feasibility study was required by DNR because of the previous monitoring.

A lake management and protection plan for White Clay Lake was developed by local residents with assistance from the Soil Conservation Service and University of Wisconsin Extension. It was presented to the lake district in May. The district approved the plan and immediately applied for financial assistance from DNR and EPA. A hearing on the application was held by DNR in June.

1976	EPA made its first award under the Federal Clean Lakes Program, White Clay Lake was the only project with work confined to watershed management. DNR funds had been approved earlier. By fall, construction had begun on land management practices and manure storage facilities.
1977-1978	Work continued on barnyard improvements such as manure storage facilities, improved feeding and exercise areas, gutters and downspouts on buildings, and diversion ditches to prevent as much water as possible from moving through the barnyard. Land management practices included streambank stabilization, animal crossings, and grassed waterways underlain by tile.
1979	The project was completed at a cost of approximately $250,000.
1977-1982	Grants from the EPA to the University of Wisconsin Extension provided for an evaluation of the limnological, social and economic impacts of the project.

Lake Stabilization Project

In contrast to Mirror Lake in Waupaca, a stabilization effort was required at White Clay Lake in order to maintain the already high level of water quality. The plan was based on the design and use of conservation practices which would reduce nutrient and sediment movement into waterways. As agriculture (dairying) is the dominant activity in the watershed, handling of animal waste was the major problem. Conservation practices include manure storage facilities, improved feeding and exercise areas, gutters and downspouts on buildings, and diversion ditches to prevent water from moving through the barnyard.

Coupled with the animal waste handling phase of the project is the installation of land control measures to reduce the movement of sediments and nutrients to the lake. These measures include: fences to protect streambank and lakeshore areas; animal crossings where needed; alternative animal watering facilities; construction of diversion ditches, grass waterways, and installation of tile. Total project cost was $214,000.

Manure Storage and Barnyard Improvements

Livestock wastes were identified as a major potential source of pollutants in the White Clay Lake Management Plan. The plan described three types of needed control practices: (1) manure storage; (2) feed and rest area waste control; and (3) clearwater collection and diversion around barnyards. The White Clay Lake Management Plan asked for a total of $149,000 to be used in improving animal waste management practices. It was soon apparent that this amount was not enough to fund the desired animal waste management practices. The total amount of $183,380 was provided by EPA and DNR to the lake district and was used for animal waste control. The originally proposed land management practices were to be funded by the more traditional County Agricultural Stabilization and Conservation Service (ASCS) cost sharing as it became available. A supplementary grant of $79,313 was received in 1979 from DNR and EPA to complete livestock waste management practices. ASCS REAP cost-sharing funded animal waste facilities at six watershed barnyards to a total amount of $16,390.

As a result of combined cost sharing dollars from three agencies (EPA, DNR, ASCS) and technical help from SCS and UW Extension, a total of 19 of the 25 farms which have the potential to impact White Clay Lake had management practices for manure handling and/or barnyard improvement installed by 1981. Eighteen of these have manure storage capabilities. Barnyard improvements, clearwater diversion and/or settling filter areas have been installed at 18 of the livestock concentration areas. Fourteen barnyards had feedlot improvements, twelve had clearwater diversions installed, and fifteen had settling filter areas installed. For more details on manure storage and other barnyard work, see Table 4.1.

Table 4.1--Design Specifications, Barnyard Runoff Controls and Manure Storage Facilities, White Clay Lake

Farm Number	Cost Share Source	Manure Storage		Storage Capacity (Cu.Ft.)	Design Animal Units	Design Storage Period (Days)	Other Barnyard Work				Type Barn
		Storage Type	Handling Method				Feedlot Improvement	Clear-water Diversion	Holding Pond	Settling Filter Area	
1	REAP ILR	CP	P	128,968	120 DC	365	yes		yes	yes	S
2	ILR	CP	Sc	19,350	60 H	365					FS
3	ILR	CP+D	P	49,400	80 DC 12 C	240	yes	yes		yes	S
4	ILR	P+P	Sc	11,250	60 H	180	yes	yes		yes	L
5	ILR	P+P	Sc	25,350	70 H	360		yes		yes	FS
6	REAP ILR	P+P P+P	Sc Sc	13,500 19,150	75 AU 80 DC 8 C	160	yes	yes		yes	S+L
7	ILR	CP	St	20,956	43 AU	180				yes	S
8	ILR	CP	P	99,700	60 DC 60 H 25 C 50 B	365	yes	yes		yes	S+FS
9	ILR	CP	St	53,353	60 AU	240	yes	yes		yes	S
10	REAP ILR	P+P	L	9,870	45 H		yes	yes		yes	S S
11	ILR	CP	St	34,020	70 AU	180	yes	yes		yes	S+L
12	ILR*	P+P	Sc	6,000*	35 S 315 FP		yes	yes		yes	
13	ILR*	P+P	St	28,800	38 C 22 H	270	yes			yes	S
14	ILR*	P+P	St	34,400*	30 DC 20 H	365				yes	S
15	ILR*	P+P		5,100*	35 H	180	yes			yes	S
16	REAP ILR*	P+P	Sc	23,400	52 AU	180	yes*	yes		yes yes	S
17	ACP	CP		41,260	64 AU	180	yes	yes			S
18	ILR						yes	yes	yes		S
19	REAP ?	CP SS	St P	48,000 47,000	100C 200C	120					F

Abreviations Used:

Cost Share Source

- REAP - ASCS REAP cost sharing
- ILR - Inland Lakes Renewal (EPA/DNR)
- ACP - ASCS ACP cost sharing

Storage Type

- CP - concrete pit
- D - dike
- P+P - post and plank

Design Animal Units

- DC - dairy cows
- H - heifers
- C - calves
- B - beef cattle
- S - sows
- FP - feeder pigs
- AU - unspecified animal units

Handling Method

- P - pump
- Sc - scraper
- St - stacker
- L - loader

Barn Type

- S - stanchion
- FS - free stall
- L - loose

* These projects funded by 1979 EPA Grant

Source: (41)

Total cost of the EPA-DNR funded animal waste management project was $292,567 with $143,200 and $119,493 covered by EPA and State cost-sharing, respectively. Total eligible improvement costs ranged from $4,426 to $43,544 and averaged $17,210. Detailed information on cost of work completed at each barnyard is contained in Table 4.2. Farmers paid at least 10 percent of the cost of the improvement projects, and as high as 34 percent when ineligible costs of stackers are considered.

Because construction of manure storage facilities and other barnyard control practices generally was done at the same time, it is not possible to determine separate costs of the practices installed. It can be seen that concrete costs were highest--representing approximately 70 percent of the total project cost. Excavation and construction costs averaged 15 percent of the total eligible cost. Pumps and stackers were also significant for those manure storage facilities which required them.

Watershed Land Management Improvements

The White Clay Lake Management Plan also identified the need for land management practices to control nutrient and sediment transport from cropland. Prior to the EPA-DNR Inland Lake ASCS funded several land management practices including a grass waterway and sediment control project which formed a one-acre pond. A total of $3,932 was spent on these projects.

Initially the White Clay Lake Management Plan requested $64,500 for land treatments. This included $6,500 to protect streambank and lakeshore areas, and to construct animal crossings and animal watering facilities where needed. An additional $55,000 was requested to construct diversion ditches, grass waterways and installation of tile where it was needed with these ditches and waterways to reduce erosion.

Table 4.2--Project Costs, Barnyard Runoff Controls and Manure Storage Facilities, White Clay Lake

Farm Number/ Program	Original Estimated Cost (Dollars)	Eligible Costs	Breakdown of Total Costs (Dollars)				
			Excavation and Construction	Pump (P) Stacker (S) or other (O)	Fencing, Lumber, Misc.	Concrete	Farmer's Time and Materials
1 REAP		~2,500 a/					
ILR	19,500	28,196	5306	6195 (P)	~207	16,103	385
2 ILR	7,100	9,516	1412		~169	7,650	285
3 ILR	26,200	35,790	3986	6893 (P)	1027	22,949	935
4 ILR	9,000	11,516	1840		~66	9,228	382
5 ILR	8,500	9,878	944			8,874	60
6 REAP		~2,500 a/					
ILR	13,203	14,849	2015		~3871	8,480	483
7 ILR	10,000	11,935	1166	3203 (S) b/	138	9,901	730
8 ILR	29,712	43,544	6210	6600 (P)	~1579	28,760	395
9 ILR		26,133	2460	2358 (S) b/	2346	21,180	147
10 ILR	7,600	8,330	1172		408	6,645	105
11 ILR		14,755	1802	2358 (S) b/	105	12,630	218
12 ILR	9,008	9,470	3066			6,134	270
13 ILR	15,872	19,784	1734	2450 (O) b/	5675	12,302	73
14 ILR	9,345	10,209	2081	3650 (S) b/	698	7,430	135
15 ILR	5,898	44,026	757			3,354	
16 REAP		~2,500 a/					
ILR	5,998	7,642	778		1443	5,301	120
17 ACP		~2,500 a/					
18 ILR	18,025	26,588	6731	4900 (P,O) b/	447	16,460	350
19		~2,500 a/					

a/Maximum allowed ASCS cost-share portion.

b/All or a portion of these costs were not eligible for cost sharing.

Source: (40)

Another $3,000 for streambank stabilization was also requested. However, between 1976 and 1980 only $8,263 was available from ASCS cost sharing.

Land management practices completed at White Clay Lake include several sod grass waterways, underlain with tile, fencing of a portion of the lake,a field diversion system, and a terrace on a steeper portion of the watershed. Two shallow wildlife ponds were also built with ASCS funds.

Since future dollars available to the White Clay Lake area must be divided among all conservation needs in the county, it is likely to be a long time before all the initially envisioned land treatment projects can be carried out.

There are several important land management practices that can be pursued without cost sharing. One of these is selection of crop rotations or a conservation cropping system appropriate to the soil and slope of each given field. By selecting a rotation with more years of hay than corn, soil loss can be reduced. Several of the farmers in the watershed have long-term cooperator agreements with SCS which include conservation cropping systems.

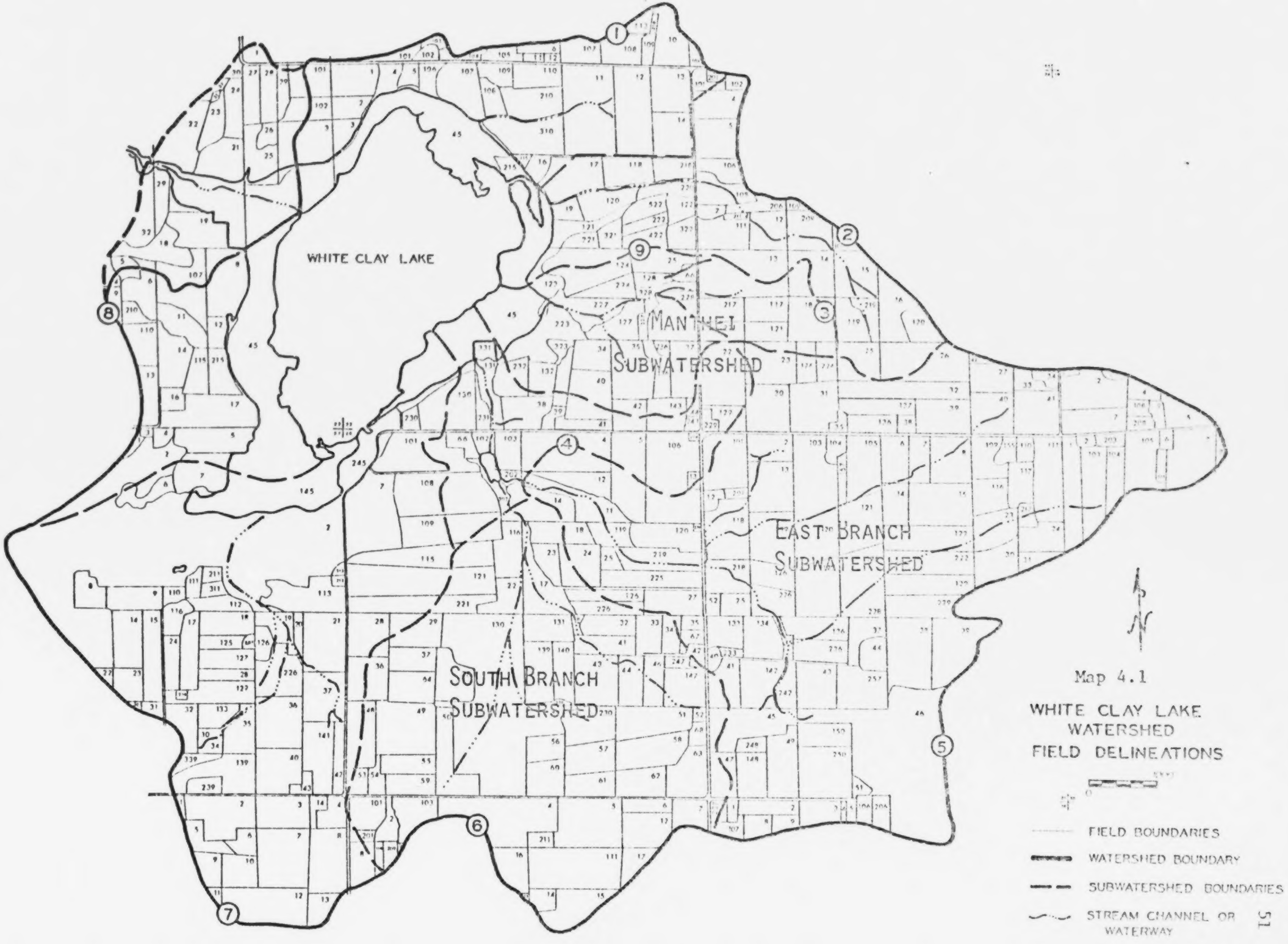
Finally, protection of the lake's water quality requires anticipation of land use changes that may jeopardize water quality. Much of the shoreland of the lake is in wetlands which appear to buffer the lake from the full impacts of nutrient and sediment loadings (21). There are also soils which are severely limited for onsite waste disposal. The White Clay Lake District choice to request that these lands be put into a ON-1 Natural Resources Preservation First Class zoning category that would protect the wetlands and lake from more development. Thus, long range protection of the lake's critical buffer area was ensured. The White Clay Lake shoreland was the first area in Shawano County to have this zoning classification.

Project Evaluation

An extensive monitoring and modeling effort was undertaken in the White Clay Lake watershed to evaluate the effectiveness of installed nonpoint source control practices. Included in this effort was monitoring of three subwatersheds shown on Map 4.1, to determine sediment and nutrient loadings (42,43), an analysis of the lakes groundwater regime (55), lake water quality monitoring (42,43), an analysis of the effect of wetlands on sediment and nutrient delivery (22), determination of long-term sediment movement based on Cesium-137 movement (33),, and an analysis of phosphorus movement in fields due to precipitation (66). A hydrologic and nutrient budget on the lake has been developed. In addition to the monitoring studies, detailed climatological information and land use data including cropping and livestock waste handling practices was collected between 1974 and 1979. Several models have been used to examine the relationship between changes in land management practices, climatic factors, and monitored sediment and nutrient loadings (40, 41). A discussion of selected aspects of several of these studies follows.

Watershed Monitoring Results

Flow monitoring devices were installed to isolate three watersheds--the south watershed of about 195 hectares, the east watershed of 328 hectares, and the Manthei watershed of 22.5 hectares (Figure 4.1). The larger two watersheds were selected to be representative of the soil, topography, and land use of the rest of the watershed as well as other areas



Map 4.1

WHITE CLAY LAKE
WATERSHED
FIELD DELINEATIONS

WHITE CLAY LAKE
MANTHEI SUBWATERSHED
EAST BRANCH SUBWATERSHED
SOUTH BRANCH SUBWATERSHED
1
2
3
4
5
6
7
8
9
N
FIELD BOUNDARIES
WATERSHED BOUNDARY
SUBWATERSHED BOUNDARIES
STREAM CHANNEL OR WATERWAY

of northeastern Wisconsin. A monitoring station on the lake's outlet stream measures output of surface water from the entire watershed. Water samples taken weekly and during runoff events at each station are analyzed for residue, phosphorus, nitrogen, and chloride content.

A survey of groundwater movement and quality in the basin complemented the hydrologic and nutrient transport studies for the lake. Observations on a network of wells and seepage collectors were used to estimate rates of water movement into the lake. Water level recorders showed the relationship between lake level and water table fluctuations. Samples from observation wells were analyzed for chloride, nitrogen, and phosphorus content. Samples from private water supplies were analyzed to determine the water quality of the deeper aquifer. Groundwater monitoring is continued on a quarterly basis.

Project weather stations within the watershed provide a continuous measurement of precipitation, temperature, and relative humidity. Maximum and minimum temperature readings are recorded weekly. Frost depth is monitored using fluorescein tubes at several places in the watershed from December through April (18).

A summary of the water, residue, phosphorus and nitrogen transport from the East Branch and South Branch subwatersheds for the period 1974-1979 is presented in Table 4.3. The variability in this monitoring data is apparent: water volume varies from the annual total of 138,825 m^3 to 1,209,815 m^3 in the East Branch. Other parameters vary in a similar manner. Observed climatic events provide some explanation. These events include heavy snowfalls in the winter of 1975-1976, a dry growing season in 1976 and subsequent dry year in 1977, and abundant snowfall in the winter of 1978-1979. Shown in Table 4.4 are total annual rainfall and

Table 4.3--Summary of Water, Phosphorus, Nitrogen, and Residue Transport

	1974	1975	1976	1977	1978	1979
East Branch						
Water volume (m^3)	405,000	616,000	682,000	138,825	238,096	1,209,815
Total phosphorus (kg)	214.6	166.9	703	85.3	50.8	293.2
Average concentration (mg/m^3)	.53	.27	1.03	.625	.213	.241
Range of concentration (mg/m^3)	(.02-6.1)	(.01-3.47)	(.01-7.85)	(.01-3.65)	(.02-5.75)	(.02-1.45)
Total nitrogen (kg)	1,660	2,221	2,552	785	1,666	5,984
Average concentration (mg/m^3)	4.10	3.61	3.74	5.65	7.00	4.94
Range of concentration (mg/m^3)	(1.8-15.5)	(1.55-26.8)	(1.57-8.18)	(1.51-16.30)	(2.60-18.30)	(1.47-8.34)
Residue (kg)	227,400	184,000	197,300	82,420	143,273	587,934
Average concentration (mg/m^3)	563	299	289	594	602	405
Range of concentration (mg/m^3)	(10-6210)	(60-164)	(29-827)	(287-1100)	(180-1030)	(257-1270)
South Branch						
Water volume (m^3)	292,000	359,000	194,000	20,438	196,058	820,790
Total phosphorus (kg)	109.00	161.60	72.10	4.05	23.20	105.40
Average concentration (mg/m^3)	.360	.450	.370	.199	.118	.128
Range of concentration (mg/m^3)	(.05-7.00)	(.01-2.93)	(.01-6.42)	(.01-4.15)	(<.01-2.77)	(.02-.60)
Total nitrogen (kg)	1,323	1,980	950	86	1,290	6,220
Average concentration (mg/m^3)	4.53	5.53	4.91	4.23	6.58	7.58
Range of concentration (mg/m^3)	(1.40-8.20)	(.55-18.80)	(1.32-12.50)	(.97-9.04)	(.32-16.20)	(.60-22.70)
Residue (kg)	145,400	125,700	78,940	8,845	101,615	453,493
Average concentration (mg/m^3)	498	350	408	433	518	552
Range of concentration (mg/m^3)	(10-6000)	(50-4100)	(250-727)	(201-755)	(88-963)	(334-814)

Source: (43); 1979 information provided by James O. Peterson, Associate Professor, University of Wisconsin-Madison.

rainfall erosion indices calculated to give some indication of the variability in climatic conditions during the period of study.

Eleven of the seventeen EPA-DNR livestock waste control facilities were completed in the fall of 1976 and summer of 1977 and the rest were completed during 1979. The amount and intensity of rainfall during 1979 tended to mask any reductions in phosphorus loading that would be attributable to the installation of all control practices. However, a comparison of average total phosphorus loading in the East Branch from 1974 to 1976 and 1977 to 1979 as shown in Table 4.5 indiates that while total rainfall and rainfall intensity averaged 128 percent and 167 percent of the earlier period, total phosphorus loading was only 39 percent of the earlier period. Thus, it appeared that the livestock and land management practices installed at White Clay Lake did help to reduce total phosphorus loading to the lake.

Lake water quality monitoring included monthly measurements of dissolved oxygen and temperature profiles, Secchi depth and laboratory analysis of water samples from the inlet, lake surface, and at 6-meter and 12-meter depths within the lake. Analyses were made for nitrate, nitrite, ammonium-N, organic nitrogen, reactive phosphorus, total phosphorus, calcium, magnesium, sodium, potassium, chloride, sulfate, alkalinity, and pH.

Part of the limnological analysis included examining the effects of littoral marshland on lake water quality. Protection of littoral zones is thought to be a critical factor in maintaining high quality of lake water. The objectives of the marsh study were to evaluate changes in surface water quality discharged from the subwatershed as it flows through the wetland and to evaluate the ability of wetland macrophytes

Table 4.4--Fluctuations in Climatic Factors Affecting White Clay Lake

	1974	1975	1976	1977	1978	1979
Annual rainfall (inches)	22.55	23.36	21.09	21.20	29.54	35.13
Storm rainfall erosion index	90.00	73.80	20.80	16.90	135.00	183.00[a]
Thaw rainfall erosion index	5.10	5.60	17.60	9.00	4.90	7.50
Annual rainfall erosion index	95.10	79.40	38.40	25.90	139.90	190.50[a]

[a] Includes an estimated value of 20 for one two-inch rainfall

Source: (40)

Table 4.5--Average Annual East Branch and White Clay Lake Loading and Climatic Conditions

	1974-76	1977-79
Annual flow (m^3)	566,667	528,912
Total phosphorus loading (kg)	361.5	142.0
Annual rainfall (cm)	22.3	28.6
Rainfall erosion index	71.0	118.8

Source: (40)

to remove nutrient and sediment loads from the surface water discharge.

Estimated Reductions in Phosphorus Loading Attributable to Livestock Waste Management Controls

Reduction in total phosphorus loading attributable to changes in livestock waste management practices were estimated using a method initially developed by Robinson and Draper (46) and later modified by Moore and Madison (36), and Moore (35) for Wisconsin. This method estimates loadings from winter-spread manure, barnyards and above ground manure storage facilities. The method provides a means of removing climatic variability from the evaluation of phosphorus reduction attributable to livestock waste practices.

Livestock numbers were determined for the years 1970, 1974 and 1978 from township tax assessor records, and farmer interviews. This information was converted into animal units (AU) assuming a milk cow equaled 1.3 AU, heifers are .8 AU, calves .25 AU, sows and gilts .25 AU and feeder pigs .05 AU. Total animal units were 1,545, 1,844 and 1,960 in 1970, 1974 and 1978, respectively.

Total phosphorus and manure production were calculated for:(1) 1970 prior to any barnyard improvement; (2) 1974 when REAP funded installation had been completed; (3) 1978 when the initial Inland Lake Protection and Renewal (ILR) funded work had been installed; and (4) the future when the additional ILR funded projects will have been completed. This calculation was based on an assumed 5 month winter period for Shawano County. Thus 5 months "manure storage capacity" for each farm is necessary to avoid winter spreading. The known manure storage capacity of each farm was then subtracted from the total calculated winter production for each year of interest. This difference (the calculated manure actually spread on fields) was assumed to be equal to the total manure actually spread in the winter by each farmer associated with the White Clay Lake watershed. The proportion of this total manure spread inside the White Clay Lake watershed boundaries was assumed to be proportional to the percentage of cropland each farmer worked within the watershed. The total phosphorus associated with this produced and spread manure was calculated using 0.033 kg and 0.068 kg per animal unit per day of dairy stock and swine, respectively.

Based on Moore, total -P runoff from winter spread manure was assumed to be 8 percent of that in the manure (35). A critical distance of 40 meters from a stream or waterway and average attenuation rate of 50 percent for winter spread manure within that critical distance was assumed.

As seen in Table 4.6, this analysis showed that while potentially deliverable total phosphorus associated with winter spread manure increased from 66.7 kg to 84.1 kg from 1970 to 1980, estimated delivery decreased from 66.7 kg to 25.9 kg.

Based on Moore, total -P runoff from barnyards was assumed to be 4 percent of the total P in manure produced annually (35). Critical distance and attenuation was similar to winter spread manure. No research was available to indicate what reduction in total -P runoff from treated barnyards would be. An assumption of 50 percent reduction in P runoff was used. Barnyard controls were estimated to reduce associated phosphorus loading from 339.6 kg to 223.8 kg in the entire watershed, and from 64.4 kg to 31.9 kg in the East Branch subwatershed. The total estimated reduction in barnyard runoff was 46 percent.

Table 4.6--Average Annual Total Phosphorus Loadings from Animal Waste

	A. EAST BRANCH WATERSHED				B. WHITE CLAY LAKE WATERSHED			
	Period I (1970 and before)		Period II (1971-1974)		Period III (1975-1978)		Period IV (1979 and future)	
Runoff Source[a]	Potentially Deliverable	With Controls	Potentially Deliverable	With Controls	Potentially Deliverable	With Controls	Potentially Deliverable	With Controls
EAST BRANCH SUBWATERSHED								
Barnyards	64.4	64.4	60	60.7	55.3	36.8	55.3	31.9
Winter Spread Manure	24.2	24.2	25	23.4	27.0	8.4	29.0	2.6
Above Ground Storage	-	-	-	-	-	1.2	-	4.7
TOTAL RUNOFF	88.6	88.6	86.0	84.1	84.3	46.4	84.3	34.5
Percent of potentially deliverable Total P	-	100	-	98	-	55	-	40
Percent of Period I loading	100	100	97	95	95	52	95	39
WHITE CLAY LAKE WATERSHED								
Barnyards	339.6	339.6	371.3	336.8	398.0	362.4	398.0	223.8
Winter Spread Manure	66.7	66.7	76.0	72.9	84.1	35.6	84.1	25.9
Above Ground Storage	-	-	-	-	-	9.7	-	13.0
TOTAL RUNOFF	406.3	406.3	447.8	409.7	482.1	307.7	482.1	262.7
Percent of potentially deliverable Total P	-	100	-	91	-	64	-	54
Percent of Period I loading	100	100	110	101	119	76	119	64

[a] Amounts are expressed in kilograms

Source: (40)

There is some total phosphorus loss associated with above-ground solid waste storage facilities. Based on Moore (1979) this was estimated to be 3 percent of the total P produced at the site annually (34). In the entire watershed in 1980 this was estimated to be 13 kg or about one-quarter of the estimated 1980 reduction in total -P runoff from winter spread manure.

Based on the analysis of manure spread, barnyard and above-ground manure storage, in 1970 presumably 100 percent of the potentially deliverable manure-associated phosphorus actually reached White Clay Lake streams. By 1978 and 1980, only 76 percent and 54 percent respectively of the potentially deliverable phosphorus reached White Clay Lake streams. While the amount of potentially deliverable phosphorus increased by 19 percent from 1970 to 1980, the loading was estimated to be reduced by 36 percent. Estimated reductions in the East Branch watershed were even greater.

Total Phosphorus Reduction

Total phosphorus availability is not only influenced by animal waste management, but also control of sediment runoff, natural background sources and septic systems. The reduction in phosphorus by animal waste management has been discussed above. Research has not been completed regarding nutrient contributions from the other potential nutrient sources. However, it is possible to make statements on total phosphorus based upon the preceding discussion on animal waste control and lake water quality monitoring efforts used to calculate the lake nutrient budget.

Critical loadings of phosphorus to lakes of the size of White Clay Lake have been indicated by Vollenweider (61). He indicated .07 $g/m^2/year$

is a permissible loading rate. Rates higher than .13 g/m^2/year are considered dangerous from the standpoint of eutrophication control. Loadings for total P to White Clay Lake were calculated to be .94, .93, 1.65, and .47 g/m^2/year in 1974, 1975, 1976 and 1977, respectively, based on monitored data and extrapolating it to the rest of the watershed. Percentage soluble P averaged 28, 20, and 40 percent of total P from surface, groundwater, and precipitation inputs, respectively. A very rough estimate of soluble P loading from all inputs would then yield .22, .26, .27, and .47 g/m^2year for 1974, 1975, 1976, and 1977. All these loadings are above those indicated to be critical loading levels if the lake is to remain oligotrophic.

It is apparent that the surface water inputs, averaging 66 percent of the total, are an important component of total and soluble phosphorus loadings to the lake. Reduction in surface water input by half would reduce loading to the lake by a third. Significant reductions in surface water loadings coupled with the continued buffering capability of the wetland, should be adequate to maintain current water quality conditions in the lake, and to prevent an acceleration of eutrophication. Additional discussion of the water quality of White Clay Lake and the level of eutrophication present is found in the following section.

Water Quality of White Clay Lake

Water quality of a lake is an elusive concept to define much less protect. In an effort to describe the water quality of White Clay Lake, measures of various water quality parameters will be provided along with classifications of water quality. In particular, the LCI which will be used in the estimation of recreation benefits.

Macrophyte Plant Communities

Sullivan conducted a detailed survey of macrophyte plant communities found in White Clay Lake (53). Fourteen species of plants were found. The four most common species were *Chara* sp., *Certatophyllum demersum*, *Myriophyllum* sp., and *Potamogeton pectinatus*.

Four major plant communities were delineated. The location of the cattail community was estimated by Sullivan from a 1967 lake survey map. Cattails encompassed 29 percent of the lake basin (53). Another emergent plant community of bulrushes was approximately 18 percent of the lake basin. The major littoral plant communities consisted of *Chara* and *Potamogeton* where the water was up to 2.5 meters deep. In depths of 2.5 to 4.0 meters, dense stands of *Ceratophyllum* and *Myriophyllum* were found.

It is likely that if the lake were completely surrounded by cottages, having 70 percent of the lakebed in littoral, and emergent plants might be considered nuisance conditions for boat access and swimming. Because the value of the marsh fringe for water quality protection is locally recognized and there is only one development on the lake, these plant growths have not been considered nuisances. The plants thus can provide habitat for fish and waterfowl.

Dissolved Oxygen

The dissolved oxygen levels found in a lake are fundamental to the distribution of biota (fish and other organisms) and nutrients in the lake. Fish generally require that 5 mg/l dissolved oxygen be maintained to avoid stressful conditions. In Wisconsin, this requirement has been formalized into a water quality standard (NR 102). The distribution of dissolved oxygen can also affect the availability of inorganic nutrients.

Phosphorus is more soluble in anaerobic conditions than in aerobic conditions. Thus, when phosphorus rich sediments are exposed to anaerobic conditions, more phosphorus becomes part of the water column than when the sediments are exposed to aerobic conditions.

Dissolved oxygen (DO) profile surveys have been made at White Clay Lake at approximately monthly intervals from 1974 to 1978. The DO patterns observed are typical of a somewhat eutrophic dimictic lake. During late winter when the lake is stratified and ice cover prevents surface atmospheric reaeration, oxygen depletion generally occurs in the lower three meters. DO levels under 5 mg/l which start to become stressful to fish are generally found below four meters in late winter. At spring, turnover dissolved oxygen becomes mixed throughout the water column. As summer progresses and the lake restratifies, the DO in the hypolimnion becomes reduced. Finally approximately a month after turnover, total oxygen depletion occurs in the lower meter and by early June extends throughout the lower six to seven meters of the lake. Five mg/l DO is generally found one meter above the area of oxygen depletion. The summer pattern of oxygen depletion has remained fairly constant at White Clay Lake, changing only with the time of spring turnover. Fall turnover, occurring in late September or early October, remixes the dissolved oxygen throughout the water column and starts the cycle again. Critical low DO concentrations have not been observed at White Clay Lake during the period of study.

Total Phosphorus and Nitrogen

Phosphorus and nitrogen are generally recognized as the two most important nutrients limiting phytoplankton growth in lakes. Because nitrogen is extremely soluble, widely dispersed, and capable of being fixed from atmospheric nitrogen by some blue-green algae, it is not generally considered to be the limiting nutrient in lakes. Phosphorus is generally considered to be limiting, if the concentration of nitrogen to phosphorus is greater than 12 to 1. Comparisons of vernal (spring turnover) concentrations of nitrogen and phosphorus in White Clay Lake (Table 4.7) indicate that the lake tends to be strongly phosphorus limited. The only exception was in 1977 when the ratio of nitrogen to phosphorus was 11 to 1.

From 1974 through 1978, chemical sampling surveys of the lake's profiles at the deepest hole have been conducted at approximately monthly intervals. Analysis for nitrate, nitrite, ammonia, organic nitrogen, total nitrogen, orthophosphorus, and total phosphorus was performed. While nitrogen is not generally considered limiting, Vollenweider has noted a direct correlation between high sustained productivity of algal populations and average concentrations of inorganic and organic nitrogen (61). These relationships and ranges are indicated in Table 4.8. White Clay Lake tends to be oligo-mesotrophic to meso-eutrophic by this analysis. Patterns of total nitrogen distribution are variable from one year to the next, generally ranging from 800 to 1200 mg/1 in the epilimnion. Higher concentrations are found in the hypolimnion during aerobic conditions. Annual variability should be recognized as being attributable to climatic and biotic differences as well as differences in annual nutrient loading. Tolman's calculation indicated an annual lake nitrogen loading of 5.5 g/m^2 of lake surface at White Clay Lake (55). This appears to be in excess of the 1.0 g/m^2 considered permissible and the 2.0 g/m^2 indicated to be dangerous by Vollenweider as levels of total nitrogen loading.

Table 4.7--Vernal Total Nitrogen and Total Phosphorus Concentrations and Ratios for White Clay Lake

	1974	1975	1976	1977	1978
Total P (μg/l)	40	20	15	60	30
Total N (μg/l)	1,141	1,130	1,000	660	1,160
Ratio N:P	29	57	67	11	39

Source (41)

Table 4.8--General Relationship of Lake Productivity to Average Concentrations of Epilimnetic Nitrogen and Total Phosphorus

General Level of Lake Productivity	Inorganic N (μg/l)	Approximate Average Organic N (μg/l)	Total Phosphorus (μg/l)
Ultra-oligotrophic	<200	<200	<5
Oligo-mesotrophic	200-100	200-100	5-10
Meso-eutrophic	300-650	400-700	10-30
Eutrophic	500-1500	700-1200	30-100
Hypereutrophic	>1500	>1200	>100

Source: (61)

Phosphorus, as the limiting nutrient, is the critical nutrient of interest. The relationship between total phosphorus to lake productivity is indicated in Table 4.8. When compared to levels found in White Clay Lake, these relations indicate that in most years, White Clay Lake tended to be near the lower end of the eutrophic scale. In 1974, there appeared to be higher levels of phosphorus than other years, especially at the time of winter snowmelt. Annual patterns of total phosphorus distribution in the water column vary considerably. However, high phosphorus levels are generally observed in the summer in the hypolimnion when anaerobic conditions exist.

Vollenweider has also given a general summary of the relationship between total phosphorus loading to a lake and the lake's productivity level (61). Annual total phosphorus loadings to White Clay Lake were .94, .93, 1.65, and .47 g/m^2 for 1974, 1975, 1976, and 1977, respectively, indicating that they are in excess of permissible and dangerous levels. The average loading during this period was 1 g/m^2.

Lake Condition Index

As was the case with Mirror/Shadow Lakes, the data on White Clay Lake was translated into a Lake Classification Index to be used in the economic evaluation which follows in Chapter 8.

White Clay Lake had been classified in Uttormark's original work as a 4 (60). More recent measurements revealed that the penalty points of some of the water quality parameters used in constructing the LCI had shifted, resulting in a new value of 5. Table 4.9 provides a comparison of Uttormark's measure with five later years.

To provide the basis for the economic analysis, it is necessary to establish what the LCI will be both with and without the project. As shown in Table 4.10, the water quality index has been estimated to remain at a five with the project, but is anticipated to deteriorate to a sixteen in 50 years without the project. For purposes of our analysis in Chapter 8, the lake is assumed to deteriorate at a constant rate. It is also assumed that after the last change, the water quality will begin to stabilize, at least for the duration of the analysis period.

Table 4.9--Classification of White Clay Lake Using the Lake Condition Index

LCI ELEMENTS	Uttormark	1974	1975	1976	1977	1978
Dissolved oxygen conditions	2	4	4	4	4	4
Typical secchi depth (transparency)	2	1	1	1	2	1
History of fish kills	0	0	0	0	0	0
Recreational use impairment	0	0	0	0	0	0
TOTAL	4	5	5	5	6	5

SOURCE: Information provided by James O. Peterson, Associate Professor, University of Wisconsin-Madison.

Table 4.10--White Clay Lake LCI With and Without Project [a]

Year	LCI (with Project)	LCI (without Project)	LCI Difference
1976	5	5	0
1980	5	6	1
1984	5	7	2
1988	5	8	3
1992	5	9	4
1996	5	10	5
2000	5	11	6
2004	5	12	7
2008	5	13	8
2012	5	14	9
2016	5	15	10
2020	5	16	11
2026	5	16	11

[a] Long-term change estimated by James Peterson, Associate Professor, Soils Department, University of Wisconsin-Madison. Linear progression of deterioration was assumed.

CHAPTER 5

SURVEY METHODS

As indicated in Chapter 2, this study began after the technical intervention had begun; therefore, it was necessary to develop an experimental design to compensate for this. This was accomplished by assuming that the study communities were similar to the rest of the state prior to the project. and any differences that now existed were atrributable for the project.

Similarly, it was necessary to project into the future with regards to the expected physical changes associated with and without the project. This was done by consulting the physical scientists who were researching the projects water quality impacts.

The following surveys were conducted as part of our evaluation. Additional information was synthesized from the extensive observations by the authors in working with many other lakeshore communities and by regular interaction with community leaders and agency personnel involved at the study sites. Finally, the property value data was collected directly from tax rolls.

Waupaca Water Quality Perception Survey

Households with telephones in the City of Waupaca served as the population for this part of the study, because the lake district has boundaries conterminous with the city and because only property owners in the city helped pay for the project. Waupaca residents were considered to be the population impacted by the Mirror and Shadow Lakes project.

Respondents were selected from the sample housing units using a controlled selection procedure designed to balance the respondents by age and sex. A random digit dialing sample scheme was used to select the sample (38). As a result, a stratified samdom sample of 574 numbers was generated. Each number in the sample was dialed until its status as a working or non-working number was determined. If the number was a working residential number, then a telephone interview was attempted with that household. Of the 574 numbers, 110 were non-working numbers, 75 were non-residential, and 215 reach rural households outside Waupaca city limits.

The total number of interviews completed was 140. Nineteen households refused. In two households the respondent was unable to participate. In two households no eligible respondent could be contacted. And in 11 cases the telephone was never answered. The response rate was 80 percent.

White Clay Lake Resident Surveys

Geographic proximity, personal interaction, and homogeneity of population, are attributes of the White Clay Lake community. The White Clay Lake District encompasses the area surrounding the lake. The lake district itself provides the only form of institutional structure. For these reasons, the White Clay Lake community boundaries were regarded as identical with lake district boundaries.

There are 39 households in the White Clay Lake community--37 of these households were contacted. Of the 37 households contacted, 35 residents agreed to be interviewed by project personnel. Of the four households that were not interviewed, two refused because they thought they were "too old to know anything about the project"; the other two could not be contacted. The non-respondents were older and either owned no property or were renting their land to others. All active farmers in the community were interviewed. The interview consisted of two portions. The first portion was oriented towards active farmers. It included detailed questions about their operation, amount of equipment, yields, etc. The second portion of the questionnaire was administered to all 35 respondents regardless of farming status or their status vis-à-vis the lake management effort. The response rate was 90 percent.

Statewide Water Quality Perception Survey

Non-institutionalized Wisconsin adults living in households with telephones served as the population of this survey.

The sample of housing units was a cross-section of housing units with telephones in Wisconsin. Respondents were selected from the sample housing units using a controlled selection procedure designed to balance the respondents by age and sex.

A variant of a random digit dialing scheme was used to select this sample, reducing the number of non-working telephone numbers selected. The sample essentially followed a multi-stage, disproportionate, stratified model (39).

An initial screening operation made it possible to divide the sample blocks of numbers into two groups: (1) a group of sample blocks having a high likelihood of containing work telephone numbers, and (2), the remaining sample of blocks judged to have a relatively small chance of yielding working telephone numbers.

The master sample was assembled by taking all the "high-yield" sample blocks of numbers and one-sixth (selected at random) of the "low-yield" blocks. For any given statewide survey, only a portion/sub-sample of the master sample is used. Once a number is used, it is discarded. One additional change has been made to the master sample to incorporate the new information obtained from the field processing of sub-samples of the master sample. This change was the creation of an additional group of blocks of numbers, referred to as the "new high-yield" group.

The "new high-yield" group are those blocks of numbers originally retained in the sample of the "low-yield" group, which at some subsequent survey yielded a working telephone number. This could happen either because the initial screening was in error or because the telephone company controlling that central office code had recently begun to issue telephone numbers in that block to subscribers.

In summary, the master sample was divided into three groups (or intermediate strata): (1) a "high-yield" group, (2) a "new high-yield" group, and (3) a "low-yield" group. The "high-yield" group fell into the sample with probability 1/1,000, while the "new high-yield" group and the "low-yield" group were selected into the sample with probability 1/6,000.

This sample was selected from the Wisconsin Survey Research Laboratory's master sample. This minimizes the chance that the same household will fall into two independent surveys conducted by the Wisconsin Survey Research Laboratory. In general, and in this study, the sub-sampling rate is the same for the "high" and the "low-yield" groups. The "new high-yield" group is sub-sampled at three times the rate used for the other two groups. As a result, survey results from this sample must be weighted. The relative weights are shown in Table 5.1 below.

Table 5.1 Relative Weights by Sample Strata

Strata	Relative Weight
High-Yield	1
New High-Yield	2
Low-Yield	6

For purposes of some of the response results, two sets of tables are provided: one for the unweighted response results and one which incorporates the weights shown in the table.

A total of 3,583 telephone numbers were generated for this state sample of housing units with telephones. Completed interviews were obtained from one in 3.24 of these numbers--a good "hit" rate for a random digit dial sample. The total number of completed interviews was 1,107. A total of 384 telephone numbers did not yield an interview. One hundred and nine of these numbers were never answered (i.e., the number when dialed produced a normal ring, but was never answered even after more than 10 calls were made). Refusals accounted for 218 of the 384 numbers. The unweighted response rate is 74 percent.

Table 5.2 shows a breakdown of these response results by "high-yield", "low-yield" and "new high-yield" categories. The response rate for the "low-yield" stratum in this table is 42 percent. It is worth noting that 11 of the 14 non-response numbers in this stratum are from telephones which are "never answered".

When these results are weighted to account for the differential sampling rates used in the strata ("high-yield", "new high-yield", or "low-yield"), the weighted response rate is 72 percent. This drop is primarily the result of the low 42 percent response rate in the "low-yield" stratum. Since this is a conservative estimate of the stratum response rate, the actual overall weighted response rate for the study is probably higher. To further illustrate the conservativeness of this weighted response rate, over one-third (34 percent) of the 27 percent non-response is accounted for by "never answered" numbers. Most of the remaining non-responses (53 percent) are refusals. If all of the "never answered" telephones were ineligible (this is probably not the case), then the response rate would move up approximately 8 points to 80 percent. In short, the true value for the weighted response rate could be anywhere between 72 and 80 percent. Additional details on the weighted response results are shown in Table 5.3.

Table 5.2 Statewide Telephone Unweighted Response Results

Stratum	Assign	Non-Sample	Possible	Completed	Non-Response	% Re-sponse Rate	% Resp. Rate If All Never Answered Were Non-Sample
High-Yield	2,009	783	1,226	912	314	74	80
Low-Yield	1,078	1,054	24	10	14	42	77
New High-Yield	495	254	241	185	56	77	80
TOTAL	3,582	2,091	1,491	1,107	384	74	80

Table 5.3 Statewide Telephone Weighted Response Result

Stratum	Assign	Non-Sample	Possible	Completed	Non-Response	% Re-sponse Rate	% Resp. Rate If all Never Answered Were Non-Sample
High-Yield	2,009	783	1,226	912	314	74	80
Low-Yield	6,468	6,324	144	60	84	42	77
New High-Yield	990	508	482	370	112	77	80
TOTAL	9,467	7,615	1,852	1,342	510	72	80

Care should be used in interpreting the above numbers. For example, the 9,467 "assigned" numbers is the number of telephone numbers which would be necessary to yield a sample of 1,342 interviews, if an equal probability random digit dial sample had been used.

Shadow and White Clay Lakes Recreational Survey

Recreationists at Shadow and White Clay Lakes served as the population for this survey. Respondents were sampled randomly from swimmers and bathers in the beach at South Park in Waupaca. Accordingly, both open water and ice fisherpersons were randomly selected at White Clay Lake. Open water fisherpersons were interviewed after fishing to insure cooperation, while ice fisherpersons were interviewed during fishing.

Fifty-seven recreational interviews were conducted at Shadow Lake and 61 at White Clay Lake on the 20 randomly selected dates listed below as illustrated in Table 5.4.

Table 5.4 Recreational Survey Schedule, 1978-79

Shadow and White Clay Lake		White Clay Lake Only	
June 15-16	Thursday & Friday	Oct. 9-10	Monday & Tuesday
July 3-4	Monday & Tuesday	Nov. 28-29	Tuesday & Wednesday
July 7-8	Friday & Saturday	Dec. 2-3	Saturday & Sunday
July 19-20	Wednesday & Thursday	Dec. 12-13	Tuesday & Wednesday
July 27-28	Thursday & Friday	Jan. 21	Sunday (Annual Ice Fishing Festival)
Aug. 20-21	Sunday & Monday		
Aug. 24-25	Thursday & Friday	Feb. 14-15	Wednesday & Thursday
Sep. 17-18	Sunday & Monday	Mar. 22-23	Thursday & Friday
		Apr. 21-22	Saturday & Sunday
		May 1-2	Tuesday & Wednesday

The user populations were estimated by head counts. At Shadow Lake user counts were taken periodically by lifeguards during the morning and afternoon. These amounts were doubled to determine the daily user rate. This method had been developed by the Milwaukee Department of Recreation and begun in Waupaca when the then Director of Waupaca Department of Recreation transferred there from Milwaukee. Consequently, user figures were available to provide a basis for sensitivity analysis.

At White Clay Lake a local resident was employed to conduct both morning and evening head counts which were screened to determine total daily user count. This count was performed for 1977-1978.

In addition to the travel-cost and water-quality perception information, recreators were questioned about the importance of water quality, who is responsible for its protection, and who should be financially responsible. Many of the same questions were used in the various surveys to facilitate comparison. Standard demographic information was also acquired during these interviews.

CHAPTER 6

ATTITUDES TOWARD WATER QUALITY

The federal Clean Lakes Program and the Wisconsin Lake Management Program assume that water quality is an important value to citizens. We asked the question directly. The responses are provided below.

Importance of Water Quality

Wisconsin is a water recreation state. Visitors from all over the world come to Wisconsin to fish, swim, boat, and enjoy Wisconsin waters. In addition to the recreational value for non-resident tourists, Wisconsin residents feel that clean water is an important factor in their quality of live.

Respondents in three of our surveys were asked the following question: "Compared to other things in your life, how important is it to you that the water in Wisconsin lakes be of high quality--is this very important to you, important, or not really important?" For results, see Table 6.1

Table 6.1--Importance of Water Quality

	Statewide	Waupaca Residents	White Clay Lake Residents
		--Percent--	
Very important	61	63	51
Important	33	32	43
Not really	5	4	3
No opinion	1	1	3
Total	100	100	100
(N)	(1342)	(140)	(35)

The respondents overwhelmingly said that water quality in Wisconsin lakes is important. Over 90 percent of each sample indicated that water quality is important or very important to them. In the State and Waupaca samples, over 60 percent indicated that water quality was very important.

Since Wisconsin residents in general place a high value on water quality, it is not surprising that the residents of study communities are no more concerned than other state residents. The lower importance attached to water quality by the respondents from White Clay Lake may suggest a more utilitarian attitude toward natural resources by farmers or may suggest that, since their local lake is clean, the issue is less apparent.

Working on a lake project may have increased concern for water quality, but the survey results do not support this assertion. Concern was apparently high throughout the state and project sites reflected the general attitude.

Few respondents indicated that water quality in Wisconsin is unimportant to them. These results suggest that degradation of Wisconsin lakes would likely lead to decreases in the quality of life for many Wisconsin citizens.

The relationship between water quality and quality of life seems more important when the question is examined closely. The respondents were asked about the importance of water quality in comparison to other things in life. These results support previous research which suggested that Wisconsin residents place a high value on the quality and availability of natural resources, especially those resources related to outdoor recreational activities. In that study over 60 percent of Wisconsin residents indicated that they were "very interested" in water quality. Only saving home energy elicited more positive responses.

These responses suggest that any attempts to stabilize or improve the quality of life for Wisconsin residents must take the quality of water in

Wisconsin lakes into consideration. Ignoring the quality of natural resources will likely lead to a decline in what residents consider to be of a high quality of life.

Use of Lakes

Two out of three Wisconsinites use lakes each year. Very few public resources are used as extensively. For most of the 65% who use lakes each year, water quality means lakes rather rivers or streams.

Recreators place particularly high value on lakes as shown in Table 6 .2

Table 6 .2--Importance of Lakes

	Shadow Lake Recreators	White Clay Lake Recreators
	---Percent---	
Extremely important	70	63
Moderately important	28	31
Slightly important	2	6
TOTAL	100	100
(N)	(57)	(62)

Table 6.3 displays the specific levels of use at the study lakes. Fishing is clearly the dominant activity at White Clay Lake. An observer who lives at the lake recorded 7,500 summer and winter recreators.

Swimming, picnicking, and walking by the lake are the primary uses of Shadow Lake. The Waupaca telephone interviews revealed that these activities were engaged in 80,000 times annually.

Note should be made of an intensive use of the lakes by about one-quarter of each local population. Residents or recreators who visit the lake more than twenty times per year are allocating a large fraction of their discretionary time to the activity. For one-quarter of the study population, Shadow Lake and White Clay Lake are probably the most significant recreational resource in their life.

Table 6.3--Use of Study Lakes

Visits per Year	Waupaca Residents	White Clay Lake Residents	Shadow Lake Recreators	White Clay Lake Recreators
		--- Percent ---		
Swimming				
0	60	100	46	100
1-5	12	0	26	0
6-10	5	0	9	0
Over 10	23	0	19	0
TOTAL	100	100	100	100
Boating				
0	63	94	100	100
1-5	27	6	0	0
6-10	6	0	0	0
Over 10	4	0	0	0
TOTAL	100	100	100	100
Picnicking				
0	36	94	90	98
1-5	45	6	8	0
6-10	10	0	0	0
Over 10	9	0	2	2
TOTAL	100	100	100	100
Walking				
0	47	69	100	
1-5	22	11	0	
6-10	14	9	0	
Over 10	17	11	0	
TOTAL	100	100	100	
Open Water Fishing				
0	65	49	90	40
1-5	19	28	5	28
6-10	5	12	5	8
Over 10	11	11	0	24
TOTAL	100	100	100	100
Ice Fishing				
0	84	57	98	55
1-5	8	20	2	19
6-10	7	12	0	8
Over 10	1	11	0	18
TOTAL	100	100	100	100
(N)	(140)	(35)	(57)	(62)

Seriousness of Lake Pollution

The majority of respondents in the statewide and Waupaca samples did not perceive lake pollution as a very serious problem (Table 6.4). However, over one-half of the respondents in the state sample did feel that lake pollution was at least a somewhat serious problem. Approximately one-fourth of the respondents in each sample felt that lake pollution was no problem. The differences between the two samples may reflect actual differences in the environment. Waupaca is an area of the state which does not suffer the degree of water quality problems common to southern and eastern portions of Wisconsin. The dense population in eastern Wisconsin puts strain on the region's lakes--a strain that may not be consistent across the state sample.

Table 6.4--Seriousness of Lake Pollution

	Statewide	Waupaca Residents
	---Percent---	
Very serious problem	22	8
Somewhat serious problem	20	22
Small problem	24	44
No problem	24	26
TOTAL	100	100
(N)	(1208)	(124)

Perception of the seriousness of lake pollution was compared with other forms of pollution: stream pollution, air pollution, noise pollution, litter, soil erosion, wildlife reduction, overpopulation, and crowded recreational facilities. No other type of pollution was rated as seriously.

CHAPTER 7

SOCIAL IMPACTS

Projects, such as those under evaluation, have a variety of costs and benefits. Some costs and benefits lend themselves to qualitative analysis, others are less amenable to quantification or may be difficult to transform into common units. Consequently, it is not always possible to compare all the costs and benefits by quantifying everything and cranking out an answer. Such attempts may omit certain costs and benefits or arbitrarily force the quantitative unit onto all costs or benefits. Such analyses encourage researchers and decision-makers to develop an unrealistic view of the world. Values are expressed in both monetary and non-monetary, often emotional terms and decision-makers cannot and should not avoid dealing with both.

Evaluations typically concentrate on the direct result of the project's technical intervention. This report is not limited to a narrow examination of dissolved oxygen changes or increase in recreational days. This chapter focuses on the social impacts that affect citizens, communities and public agencies in non-monetary ways.

Social Benefits to Individuals

Knowledge of Lake Ecosystems

One byproduct of lake protection and rehabilitation projects may be increased knowledge of lake ecosystems.

The following questions were asked of the statewide sample of Wisconsin adults, a sample of Waupaca residents, and all household heads at White Clay Lake: (The correct response is underlined.)

1. City and village storm drains can empty into nearby lakes without hurting the quality of lake water. Agree or diagree?

2. The major cause of lake fish dying--or fish kills--in the winter months is that the water gets too cold for the fish to live.
   Agree or diagree?

3. If farmers near lakes fertilize their fields by spreading manure only in the winter, the amount of pollutants running into the lakes would be reduced.
   Agree or disagree?

4. Marshes around lakes act as a filter because they keep out material which would otherwise pollute lakes.
   Agree or disagree.

5. The lakes would always remain clear, clean and fresh if there were no people around to cause pollution.
   Agree or disagree?

Table 7.1 indicates that White Clay Lake residents scored high on four of the five questions relative to state and Waupaca residents. White Clay Lake respondents were much more likely to understand the role of marshes in protecting water quality by filtering out nutrients from the runoff. The questions on manure spreading and storm drains also indicate that White Clay Lake respondents understand the role that nutrients play in eutrophication, and the source of those nutrients. The White Clay Lake respondents seemed to understand that winter fish kills result from lack of oxygen in the water, not from water temperature.

Table 7.1 Knowledge of Lake Processes in Percent Correct Responses

Questions	Statewide	Waupaca Residents	White Clay Lake Residents
Storm drains	69	73	80
Marshes	60	58	86
Manure spreading	49	45	71
Fishkill (too cold)	72	70	97
Man as cause of eutrophication	39	41	31
(N)	(1,342)	(140)	(35)

Waupaca respondents did not score substantially above 50 percent--the score expected by simple chance. Waupaca residents, however, scored highest on the question of storm drains which was the central component of their lake project. In general, Waupaca residents showed no greater understanding of lakes than was true for the statewide sample.

None of the three sets of respondents understood the concept of natural eutrophication and death of lakes. Apparently, the emphasis on controlling cultural eutrophication has served to highlight the impact of man and underestimate the impact of natural evolutionary processes.

In summary, there is no evidence that Waupaca residents learned much about lakes as a result of the project. White Clay Lake residents either learned a great deal during the project or were more aware than average citizens based on their rural background and farm operation. An analysis of residency within the statewide survey, however, showed no consistent relationship to knowledge of lakes. The White Clay Lake residents apparently acquired their knowledge from the project.

Ascription of Responsibility

Citizens who take personal responsibility for the consequences of their actions are most likely to exhibit environmentally sensitive behavior. If they ascribe responsibility to self, they are less likely to litter or engage in other harmful behavior (19).

People in Waupaca and around White Clay Lake have experienced several years of local activity in protection and rehabilitation of lakes. Some people have devoted many days to the project. Some farmers at White Clay Lake hosted scores of visiting groups who wanted to see a manure pit in operation.

Table 7.2 shows who these citizens feel has primary responsibility for protecting water quality in Wisconsin. The table also shows comparisons with recreators at each location and with a statewide sample of adults. None of the groups rate the federal government high. Recreators, who rely on public access and purchase fishing licenses from the DNR, rate the state highest. White Clay Lake residents, who were heavily involved with the projects on their own land, feel individuals have primary responsibility for protecting lakes. This attitude is somewhat stronger at White Clay Lake than for the state as a whole and substantially stronger than at Waupaca. Comparing place of residence with perception of primary responsibility showed little relationship; again, these differences cannot be explained as a rural/urban difference. White Clay Lake residents apparently developed the feeling of responsibility as a result of the project.

White Clay Lake residents would thus be expected to exhibit concern in other environmental matters as ascription of responsibility generalizes from manure management to soil erosion and potentially to other environmental issues such as pesticide use.

There is, however, a negative corollary exhibited by White Clay Lake residents. They received a high rate of cost sharing for their project, and they have developed the strongest expectation of financial assistance from these sources. When asked to rank who should pay for monitoring or improving lake quality, White Clay Lake residents rated the state and federal governments higher and lake property owners lower than any of the other respondent groups.

White Clay Lake residents appear most likely to take initiative but also most likely to expect assistance. We cannot predict whether the

Table 7.2 Perception of Primary Responsibility for Protecting the Quality of Wisconsin's Lakes

Focus of Responsibility	Statewide	Waupaca Residents	White Clay Lake Residents	Shadow Lake Recreators	White Clay Lake Recreators
			---Percent--		
Individual citizens	38	33	45	32	37
Local government	23	30	29	21	21
State government	30	32	23	44	42
Federal government	9	5	3	3	--
TOTAL	100	100	100	100	100
(N)	(1265)	(126)	(35)	(57)	(62)

ascription of responsibility would be strong enough to motivate behavior if major expenses were involved and no outside financial aid was forthcoming.

Citizen Participation

The institutional development of a lake district at White Clay Lake demanded significant involvement by residents of the small community; the residents responded. In Waupaca, residents could rely on their regularly elected city council to make decisions and they were apparently willing to trust the council's judgment. The council was required to hold annual lake district meetings, but only two percent of the citizens ever attended an annual meeting. In contrast, nearly half of White Clay Lake residents attended lake district meetings; 14 percent attended as many as eight annual and special meetings (Table 7.3)

Table 7.3 Number of Lake District Meetings Attended

Number of Meetings	Waupaca Residents	White Clay Lake Residents
0	98	51
1	0	9
2	2	6
3	0	14
4	0	3
5	0	3
6	0	0
7	0	0
8	0	14
TOTAL	100%	100%
(N)	(140)	(35)

In Waupaca, 40 percent of the residents were not aware of the project even though the rerouting of storm sewers was a very visible project; it disrupted streets for an entire summer. Only 26 percent were aware that a local lake district was involved in the project.

At White Clay Lake half of all families attended meetings on the district before its formation (Table 7.4) and all families were aware of the project and the role of their local lake district.

Table 7.4 Number of Meetings Attended Prior to Formation of Lake District

Number of Meetings	Waupaca Residents	White Clay Lake Residents
0	98	48
1	0	9
2	1	14
3	1	6
4	0	20
5	0	3
TOTAL	100%	100%
(N)	(140)	(35)

Certainly, the process of creating a new structure at White Clay Lake carried over into involvement in the operation of the district. Waupaca residents who were not involved in creation of their districts continued to trust their council and did not participate in lake district operation. This behavior is rational and efficient; after all, the council was elected to represent the voters and govern according to their best judgment. However, the Waupaca lake project provided little experience in self-governance--experience that is important in training new leaders and keeping citizens aware of decision-making processes. The capacity for self-governance was enhanced at White Clay Lake; it was largely unchanged at Waupaca.

Improved Organizational Skills/Leadership Development

White Clay Lake residents not only attended numerous lake district meetings, they ran the meetings. With assistance from University Extension and Soil Conservation personnel, citizens established boundaries and organized the district. The town board formally created the district after a consensus had been reached in the community. The town board served as the initial commissioners of the lake district. However, when state law was changed to allow such districts to elect their own commissioners, White Clay Lake residents opted to do so. The lake district chairperson, who had become well known for his lake work, was later elected to the town board. The lake district developed new leaders and provided a "training ground" for residents who could contribute in other public capacities as well. Seventy-six percent of White Clay Lake residents said the experience had benefitted them personally. The question was not asked at Waupaca.

Social Benefits to the Study Communities

Communities are composed of people with a shared identity. A project which affects individuals in the community is likely to have an overall effect on the community as a whole. The effect on the community is not a simple sum of the effects on individuals, however. The collective attributes of the community may be impacted *per se*.

Community Development

Action by local residents to solve a common problem (e.g., lake eutrophication) may result in many changes in the community. The process of local citizens taking the initiative, organizing and setting goals, exploring alternative solutions and taking action can be viewed as community development. Community development as a process helps a community and its residents build the capacity for improved decision-making and problem-solving. This development of the community's capacity for self-governance at Waupaca and White Clay Lake was influenced by several factors.

First, the projects were not initiated by an outside agency. The local residents perceived a problem with the resource and began soliciting ideas on the causes, consequences and solutions. This process began at the local level and was fueled by the enthusiasm of residents. At this stage, local residents began seeking technical information and assistance from outside agencies. Control over the project remained at the community level. The community residents, with advice from others, determined their goals, set priorities, examined alternative solutions, and decided upon a course of action.

While technical and financial assistance was necessary from outside agencies, the community was responsible for initiating and carrying out the project. Participation by a broad range of residents at White Clay Lake helped district leaders define what local farmers wanted. Such participation may also assist residents in overcoming the alienation often associated with a "mass society".

At White Clay Lake, a major benefit of the project is the improved organizational skills and development of new local leaders. As a result of lake project participation, several residents have improved their skills at organizing and reaching decisions. This may be especially important in solving future community problems. The community has increased its capacity to solve local problems.

Coping with Bureaucracy

Communities depend on state and federal agencies for a complex assortment of regulations, technical assistance, and financial aids. Many local communities are not able to effectively decipher administrative codes and bureaucratic red tape.

Success in completing a major project provides the community with leaders who have gained specific skills and general confidence which can be applied to new programs. The community becomes bolder in seeking further assistance and less willing to be intimidated by far-away bureaucrats.

Forty-eight percent of the respondents in White Clay Lake felt that the community had gained valuable knowledge and experience through the lake management effort. The other half did not feel the experience would prove useful to the community again. In Waupaca, 34 percent of the respondents felt that the experiences would prove to be valuable in the future. Most of the other respondents from Waupaca were unaware of the project.

Community Cohesion

There was little evidence that residents of Waupaca felt the project had damaged community development or community cohesion. At no time did the project open or reopen wounds or cause new battles between segments of the community. The lake project was not the type of development that pitted old against young, newcomers against traditional families, or developers against environmentalists.

At White Clay Lake, the project provided a major community focal point. The residents had never been organized before. They had never met as a group. They had never coped with a common issue before. There were a few disagreements about spending the state and federal dollars; however, *esprit de corps* appeared to grow throughout the project period.

Community Image

Both projects received extensive publicity in the electronic and print media. The communities, especially White Clay Lake, became known as innovators in lake management. The Wisconsin Inland Lake Protection and Rehabilitation Council toured both project sites. Numerous other groups toured White Clay Lake. Leaders in the White Clay Lake effort received awards from the Wisconsin Association of Soil and Water Conservation District.

White Clay Lake had been a geographic area in the Town of Washington, Shawano County. After the project, it was perceived by the outside world as a community with a protected lake. Most, if not all of the residents, also perceived a greater sense of community. The district was proud of its accomplishments and the attention it had received.

When asked how the project had changed the community, 36 percent at Waupaca and 40 percent at White Clay Lake said the project had made the community more desirable. Other Waupaca respondents felt that the project had not changed the community. One person at White Clay Lake felt the project had made the community less desirable as a place to live in. Given that residents of both communities were happy with the community before the projects, the most accurate way to describe the impact of the projects is that they helped maintain that desirability.

Impact on Public Agencies

The success or failure of local projects not only impacts the local community, but also the funding agency. The perception of the agency by local communities, administrators and legislators are impacted. Those perceptions eventually translate into program cuts or budget increases. All agencies are aware of these impacts and anxiously await success stories.

The impact on public agencies is not only the result of the project's success in water quality terms. It also depends on the process in human relation terms.

Awareness of Agency Activities

Respondents were asked whether they were aware of water quality efforts by various agencies. From Table 7.5 it is clear that DNR is best known as a water quality agency.

Table 7.5 Respondents Who Were Aware of Agency Water Quality Protection Activities

Agencies	Statewide	Waupaca Residents	White Clay Lake Residents
		---Percent---	
U.S. Environmental Protection Agency	35	26	89
Wisconsin Department of Natural Resources	66	61	91
University of Wisconsin Extension	28	34	77
U.S. Soil Conservation Service	38	38	80
Regional Planning Commission	25	23	68
(N)	(1342)	(140)	(35)

Waupaca residents perceived agency involvement in water quality protection at about the same level as the statewide average. The project apparently had little impact on perception except a minor increase in awareness of University of Wisconsin Extension (UWEX) involvement.

At White Clay Lake the recognition of agency involvement in water quality protection shows strong impact of the project. All agencies are recognized for their involvement. Recognition levels for EPA are higher than the statewide control (35 versus 89 percent). UWEX levels are higher (28 versus 77 percent). The other agency increases are significant as well.

The most significant result is the lack of recognition of EPA at Waupaca and the strong recognition at White Clay Lake. While the Waupaca project went smoothly from the viewpoint of DNR and EPA administrators, it did not achieve much visibility with citizens. The intense involvement of citizens at White Clay Lake may have made the process a little more awkward for administrators who preferred the efficiency of full-time municipal professionals at Waupaca, but little visibility was achieved without it.

Confidence in Public Agencies

Beyond awareness of an agency's activities, citizens evaluation of these activities is critical to overall agency image and public support. Respondents were asked to evaluate whether EPA, Wisconsin DNR, UWEX, U.S. Soil Conservation Service, and Regional Planning Commissions were doing an excellent, good, fair or poor job on water quality protection. Without the project, the respondents in the study communities were assumed to respond similarly to the statewide control sample.

Table 7.6 suggests that there are major differences between the sample communities and the state sample. Respondents in the study communities felt most agencies were doing a better job with respect to water quality than the respondents in the state sample. The only exception was DNR. White Clay Lake residents rated DNR lower than the statewide sample. This is most likely a result of the general rural attitude toward DNR rather than the result of experiences with DNR on the project. Because of the historical involvement of UWEX and the Soil Conservation Service, DNR's role in the White Clay Lake project was more limited than its role at Waupaca or other lake projects in Wisconsin.

Table 7.6 Excellent or Good Ratings on Agency Water Quality Protection Activities by Respondents Who Were Aware of the Agency's Activity

Agency	Statewide	Waupaca Residents	White Clay Lake Residents
U.S. Environmental Protection Agency	49% (416)	68% (34)	55% (31)
Wisconsin Department of Natural Resources	56% (820)	72% (82)	47% (32)
University of Wisconsin Extension	74% (316)	86% (47)	74% (27)
U.S. Soil Conservation Service	60% (417)	84% (51)	75% (28)
Regional Planning Commission	42% (296)	78% (27)	42% (24)
(Number of responses)			

A breakdown of evaluations for each agency is presented in Tables 7.7 to 7.11. The data are only presented for respondents who were aware of the agency's water protection activities and were willing to evaluate these activities. The agency most active in each community received the highest rating in that community. DNR received a 72 percent approval rating at Waupaca. White Clay Lake residents gave UWEX a 74 percent approval rating and 75 percent to the Soil Conservation Service. The statewide survey also used to analyze differences due to size of place of residency. Rural people tended to rate the agencies somewhat higher except DNR which urban folk rated higher than their rural counterparts.

Table 7.7 How Good of a Job is the Environmental Protection Agency Doing in Respect to Protection of Water Quality?

Rating	Statewide	Waupaca Residents	White Clay Lake Residents
		---Percent---	
Excellent	4	3	3
Good	45	65	52
Fair	42	32	42
Poor	9	0	3
TOTAL	100	100	100
(N)	(416)	(34)	(31)

Table 7.8 How Good of a Job is the Department of Natural Resources Doing in Respect to Protection of Water Quality?

Rating	Statewide	Waupaca Residents	White Clay Lake Residents
		---Percent---	
Excellent	5	6	0
Good	51	66	47
Fair	34	23	31
Poor	10	5	22
TOTAL	100	100	100
(N)	(820)	(82)	(32)

Table 7.9 How Good of a Job is the University of Wisconsin Extension Doing in Respect to Protection of Water Quality?

Rating	Statewide	Waupaca Residents	White Clay Lake Residents
		---Percent---	
Excellent	10	23	7
Good	64	63	67
Fair	23	12	18
Poor	3	2	4
TOTAL	100	100	100
(N)	(316)	(47)	(37)

Table 7.10 How Good of a Job is the U.S. Soil Conservation Service Doing in Respect to Protection of Water Quality?

Rating	Statewide	Waupaca Residents	White Clay Lake Residents
		---Percent---	
Excellent	6	12	4
Good	54	72	71
Fair	34	12	18
Poor	6	4	7
TOTAL	100	100	100
(N)	(417)	(51)	(28)

Table 7.11 How Good of a Job are the Regional Planning Commission Doing in Respect to Protection of Water Quality?

Rating	Statewide	Waupaca Residents	White Clay Lake Residents
		---Percent---	
Excellent	3	11	0
Good	39	67	42
Fair	44	22	50
Poor	14	0	8
TOTAL	100	100	100
(N)	(296)	(27)	(24)

Social Costs

Many projects, which are justified in economic terms, have major social costs to certain setments of the population. For instance, the construction of the Alaskan pipeline created a demand for housing and other facilities that literally drove certain groups of long-term residents out of Fairbanks because they could not or would not compete in the new social environment and inflated prices (9).

The two case study projects did not have any such effect. The social costs did not appear to be significant to any group of the respondents. This lack of social costs, relative to many projects, may be the most significant social benefit. The projects did not disrupt individual lives.

CHAPTER 8

ECONOMIC ANALYSIS: MODEL SPECIFICATIONS

Once a project and its objectives have been clearly defined, the next major steps in performing an economic analysis are to properly identify and quantify the associated impacts. In both of the project settings it is hypothesized that the primary benefits generated will be recreational in nature. This is consistent with other studies that have estimated that recreational impacts will comprise anywhere from 50 to 95 percent of the project benefits (1, 63). In the case of Mirror and Shadow Lakes in Waupaca, it is plausible to expect additional benefits in the form of aesthetics. And at White Clay Lake it was realized that the adoption of the manure storage facilities may impact the farm enterprise as well. The models to be employed to estimate these impacts one must account for the change in water quality as well as provide for an *ex ante* analysis. These models are described below.

To estimate impacts at Waupaca, both a property value impact model and recreation demand model were used. Both utilize a water quality explanatory variable. A property value impact model is employed based on the hypothesis that all local benefits will be capitalized in property values.

The estimation of recreation benefits allows a check on the estimate generated by the property value model. Since most water quality impacts are assumed to reside in recreational benefits, one would expect, once having made allowance for benefits accruing to nonlocal recreators, that the recreational benefits estimate will approximate, but be smaller than property value impacts. Therefore, the recreation model provides an estimate of the recreational component of benefits, as well as of other impacts by calculating the difference between the estimates of the two methods. And, finally, it provides an estimate of the benefits accruing to nonlocal recreators that are not included in the estimate of property value impacts.

The same recreational model that was used for the Waupaca analysis was used for White Clay Lake analysis. However, since the project area is strictly agricultural, it was deemed appropriate that a linear program (LP) model be used to simulate farm activity to determine other project impacts, rather than employing a property value impact model as in Waupaca.

Property Value Impact Model

In this section a property value impact model will be described. This model was developed in an earlier study to estimate water quality benefits, the interested reader is referred to Dornbusch for a more detailed presentation (10). The application of the model is presented in Chapter 9 for the city of Waupaca.

The basic premise of this theoretical section is that water resource projects have value to the general public which, in the absence of a market in which this output is directly sold, are capitalized in the market prices of those properties situated near the resource.

Often a public project serves to enhance the productivity or utility of a specific location. Whenever this occurs, benefits accrue to firms and households in that location. This effect of increasing the value of certain locations results in the initial equilibrium in the land market being disturbed. Eventually new equilibrium land values are established. The total benefits from such programs equal the sum of the changes in productivity and utility over all firms and households; this is represented by the sum of the changes in land values from the initial equilibrium to the new equilibrium (27).

Classical rent theory asserts that productivity differentials will yield differential rents to land and therefore different land values. The rationale is that the rental value of a piece of land is bid up until it eliminates the surplus or profit (13). Benefits can be measured then by the changes in these rents. However, in order that changes in land prices accurately reflect benefits, it is necessary that all surpluses resulting from water quality changes be eliminated by the land market and that there be no induced changes in the prices of other goods to households. Freeman states, that where land is used for residential and private recreational purposes rather than for production for the market, the "no price change" assumption seems reasonable and the zero surplus assumption may be reasonable under conditions analogous to the open city model as would be the case of a small lake which is part of a much larger urban housing market (13, p. 148). These conditions are closely approximated in Waupaca thereby allowing the application of the property value model. If these assumptions are unreasonable it is possible to assume that there is no change in consumer surplus. This is accomplished by indexing the property market by distance to the water, thereby creating a situation where the supply of property is constant and perfectly inelastic and hence no available surpluses with demand shifts (10).

The benefits from a water resource depend on both the quantity and quality of the resource available to the consumer. The quantity of benefits or services from a water resource is a function of one's accessibility to that water resource. It is reasonable to assume then that more benefits accrue to residents living closer to the resource than do those living further away. Consequently, the benefits from a change in the water quality, and hence its effect on property values, will diminish with greater distance from the water resource.

Also, the magnitude of property value changes depends in part on the amount of land which is considered to be impacted by the project. Industrial land benefits are excluded since industrial production costs are relatively insensitive to water quality, and property value benefits for these lands are expected to be too insignificant to warrant their inclusion (10, pp.75-97). Since we are dealing with only day trippers and primarily local recreators it is assumed in this case, that commercial impacts would be minimal. Consequently, the impact of water quality improvements in a public park are considered only with respect to residential property values in this model.

The qualitative aspect of the causality that has been postulated between a change in water quality and property values can be demonstrated in Figure 8.1. Consider the initial demand for housing, D(DQ), given the fixed supply, S_i at distance DW_i. The equilibrium price under these conditions is P_i. Now, consider an increase in water quality which shifts the demand curve to D(WQ*). The new equilibrium price is now increased to P_i^*. This change in price reflects the change in willingness to pay for a change in water quality.

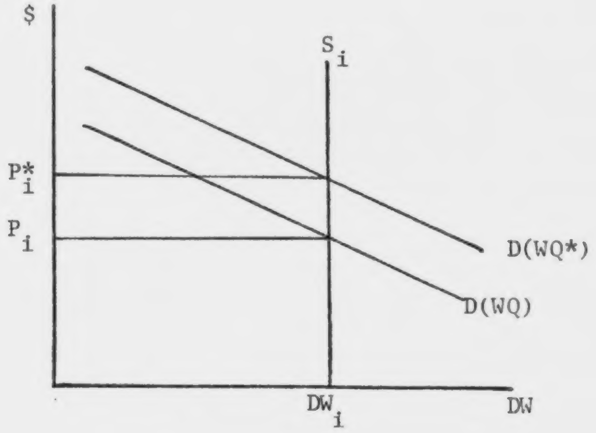


Figure 8.1--Demand for Housing

Thus, the basic model postulates first that a perceived change in water quality by area residents will be represented by a change in property values and secondly that the impact on property values decreases as distance from the resource increases. As pointed out by Dornbusch, economic theory provides few clues as to the functional forms appropriate of economic relationships, and the presence of random error terms in stochostically specified equations adds an element of ambiguity; therefore it is necessary to deduce the appropriate form from earlier studies of both theoretical and empirical nature (10). However, Freeman has shown that these earlier studies provide only one point on the consumer's marginal value curve, and therefore, do not provide sufficient information to identify the demand curve for water quality (13). To deal with this problem a two-step procedure utilizing pooled data from a number of study sites was employed (10). The first step estimates property price change functions across submarkets indexed by distance to the water's edge. In the second stage, all the site analyses are pooled. With the assumption consumers behave alike across sites the sites specific estimates can be interpreted as point estimates of the same marginal utility curve and can be combined to identify the marginal utility function which can be used to estimate the benefits from future water quality changes.

In the first step of the estimating procedure the site-specific model is represented by the general function:

$$\Delta P_{ij} = f_i(DW_{ij}, PWQI_{ij}, A_{ij}, u_{ij}) \qquad (8.1)$$

where ΔP_{ij} is the observed price change for property i at site j, DW_{ij} is the quantity of water resources that is approximated by a function of the property's distance to the water's edge; $PWQI_{ij}$ developed in Chapter 3 represents the quality of water resources, A_{ij} is all other site amenities, and u_{ij} is the random error term.

Given that it is the change in prices from one period to the next that is of interest as well as the change in PWQI and A variables the statistical model can be specified as follows: 3/

$$\Delta P\% = \beta_{oj} + \beta_{1j}(1/DW_j) + \sum_{i=2}^{n} \beta_{ij} A_{ij} + u_{ij} \qquad (8.2)$$

where ΔP% equals the percentage change in property value at the different sites and 1/DW reflects the hypothesized inverse relationship between change in property value and distance to the resource. This model is estimated of each of the various sites. See Appendix B of Dornbusch for details of each study site (10).

The second step requires the estimation of b_{1j} in the generic model

$$\Delta P\%_j = b_{oj} + b_{1j}\ (1/DW_j). \qquad (8.4)$$

This is accomplished by regressing the observed variation in the estimate b_{1j} across sites against perceived water quality and water body characteristics such as public access (PA), water body type (WBT), and water body size (WBS) at the various sites, i.e.,

$$b_{1j} = f(PWQI_j, PA_j, WBT_j, WBS_j, v_{ij}). \qquad (8.5)$$

A two stage least-squares procedure was used to estimate B_1 due to the simultaenity problem created by the variable $PWQI_{Res}$ which becomes endogenous, as specified in equation (3.2), and the same exogenous variable water body type that appears in both equations. Result of this procedure is:

$$\ln b_i = 6.398 + .492\ (\ln \mathrm{PWQI}_{Res}) + 1.180\ (\mathrm{WBT\ Lake}) + .991\ (\mathrm{WBT\ Bay}) \qquad (8.6)$$

(t-statistic) (3.438) (3.416) (2.562)

$R^2 = .948$

d.f. = 13

It is assumed in the generic model represented in equation (8.4) that $E\ (b_{1j}) = \beta_{1j}$; and that the individual site estimates represent points on a marginal value function which is common to all consumers, thus permitting the evaluation of water quality change.

The final, estimated, property value impact model to be employed in the forecasting of the economic benefits of a water quality improvement for Mirror and Shadow Lakes is:

$$\Delta P\%_d = b_o + b_1\ (1/DW_d) \qquad (8.4)$$

$$b_1 = e^{6.398}(\mathrm{PWQI}_{Res})^{0.492} e^{1.180\ (\mathrm{WBT\ Lake})} \qquad (8.6)$$

$$\mathrm{PWQI}_{Res} = -24.778 + 0.463\ (\mathrm{PWQI}_{Exp}) + 15.50\ (\mathrm{Public\ Access}) \qquad (3.2)$$

$$b_o = b_1\ (1/DW_{max}) \qquad (8.8)$$

Equations (8.8) completes the model as ΔP% must be equal to zero at the outer edge of the impact area. Since $b_1(1/DW)$ is never zero then an offsetting term is needed to bring the property value to zero for the limiting value of DW--equation (8.8) performs this role. The subscript d is added to equation (8.4) as the evaluation will be conducted by distance determined zones.

Recreation Benefit Model

Although it is argued here that the property value model presented above ostensibly captures all local project benefits, most researchers realize that the benefits estimated are incomplete to the extent that benefits accruing to the users who come from outside the project area are not reflected in property values. [4/] Consequently, it is necessary to employ an approach that will complement the property value model and estimate these benefits.[5/]

This issue will be addressed by employing the method proposed by Bouwes et al., viz., by: (1) presenting a theoretical foundation from which an empirical analysis will build; (2) establishing a framework by which water quality can be accounted for in the model; (3) presenting a model which includes the essential water quality variable; and (4) synthesizing these components by advancing a method which can be applied *ex ante* to decision making situations (2).

The Theoretical Model

Consistent with the framework by Mäler, an individual's utility is represented as a function of consumption activities, A, and environmental services, E:

$$U = U(A, E), \qquad (8.9)$$

where the utility function, U, is assumed to be quasi-concave, continuous and increasing in A and E, and consumer preference functions are assumed to be convex (29). By assuming the existence of weak complementarity, e.g., those situations where the consumption of a private good, such as swimming in lake (A_1), is a necessary prerequisite of the enjoyment of a given environmental quality, such as water quality of that lake (E_1), then it is possible to derive the benefits (costs) of a quality change in a public good (environmental service) from information on the demand for the private good. This condition of weak complementarity is expressed in mathematical terms by:

$$\frac{\partial\ U(0,A_2,\ldots,\ A_m,\ E_1,\ldots,E_n)}{\partial\ E_1} = 0 \qquad (8.10)$$

where consumption $A = A_1,\ldots,\ A_m$ and the accompanying environmental service $E = E_1,\ldots,E_n$.

Also embodied in this notion of weak complimentarity is the assumption that there are no option values, or that if the demand for some private good is zero, then so is the marginal willingness to pay for some environmental quality. An example is the case of water-related recreation, the use of which is influenced by the level of water quality. Those who would not use the lake are then assumed to be indifferent to changes in water quality.

It can now be shown that if condition (8.10) exists, and if there is no option value it is possible to compute the demand price for the environmental service. Consider the income compensated demand curve D, for recreation trips when quality of water is WQ as depicted in Figure 8.2. At the price P the recreator demands T trips, and the consumer surplus is the triangle ABC. If the level of water quality increases to WQ^*, it is assumed to increase the marginal utility per trip and shift the demand curve to position D^*; the recreator now demands T* trips. The new consumer surplus is the area DEC, and the net change in consumer surplus is given by the area BADE. [6/] The question to be answered is how much is the consumer willing to pay for this change in water quality?

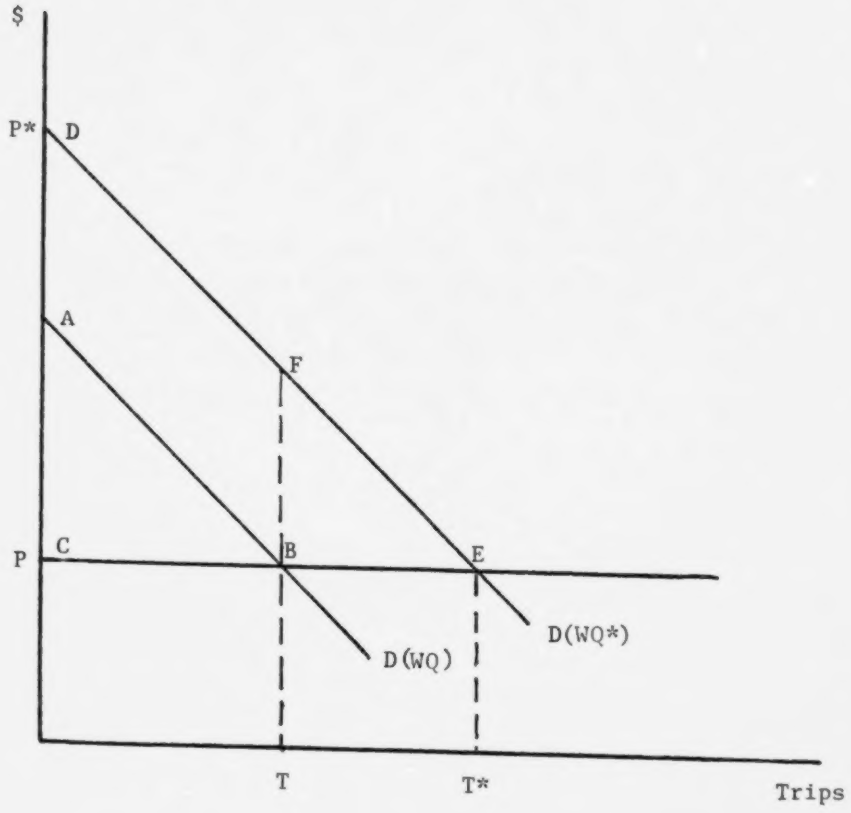


Figure 8.2--Benefits Under Complementing Conditions

Calculation of the benefits associated with a change in water quality as represented by willingness to pay can proceed in three stages: (a) A change in price from P to P^*: given the demand curve D, the individual must be compensated by the corresponding consumer surplus ABC so as not to be made worse off by the price change; (b) A change in water quality from WQ to WQ^*: given the assumption of weak complementarity, the consumer's utility is unaffected and thus there is no need for compensation; (c) A change in price back to P: the consumer is willing to pay the new consumer surplus as represented by the area DEC. The net result is the difference between the sonsumer surplus before and after the water quality change. In other words, the consumer would be willing to pay BADE for some improvement in water quality. The first step in making such a determination is the estimation of the demand curve for recreation, as measured by trips (T), that is a function of water quality.

The Travel Cost Model

Most recreational demand curve estimation procedures are based upon the travel-cost approach proposed by Hotelling (20). This method hypothesizes that recreational demand estimations can be made by examining the correlation between the recreator's frequency of visits and costs (money, time, etc.) incurred. The resulting estimated demand schedules can then be used to predict how recreators will react to price changes of the recreation site thus allowing for the estimation of the site demand durve and consumer surplus.

This approach has been refined over the years by Trice and Wood (56). Clawson (5), Kneese (25) and others. More recent statistical sophistications have been made through the use of individual observations rather than grouped data allowing better model specifications and more accurate resource evaluations (3), (16). All of these methods have been applied to evaluating the total recreational resource, but not in assessing the impact of a resource attribute such as water quality.

Some of the more recent efforts to estimate the effect of a change in water quality on the value of recreation resources have concentrated on the estimation of those benefits that would be attributable to the change in one or more physical parameters that contribute to the quality of water, e.g., recreation benefits increase as the dissolved oxygen concentration level rises (25), (7). Stevens hypothesized that the quality of the recreation experience (fishing) is a function of angling success which is a function of water quality (50). Reiling et al. employed use-intensity factors of water related activities that were supplied by Forest Service and Environmental Protection Agency personnel (45). The major shortcoming of these efforts is that the techniques do not contain a systematic relationship between the subjective index used as a proxy for water quality and the physically measurable water quality parameters, and perhaps more importantly, with recreators' perception of water quality.

Objective and Subjective Water Quality Relationship

Ultimately, the eixstence or nonexistence of benefits from a water quality change are determined by whether the water user recognizes an improvement. If an actual water quality change remains unnoticed, or if what is noticed is not valued by the recreationists, no benefits will result. In order to estimate *ex ante* the benefits that will accrue to recreationists as a result of a water quality improvement, it is necessary to predict how lake users perceive water quality.

Since water resource experts use objective and sophisticated criteria such as dissolved oxygen content, biochemical oxygen demand in parts per million and turbidity standards, it is necessary to determine the relationship between this objective rating of water quality and the typical recreator's subjective rating.

To ascertain if such a relationship exists it was necessary to seek an objective water quality index. The choice was Uttormark's Lake Condition Index (LCI), which was presented in Chapters 3 and 4.

The relationship between the LCI and subjective water quality ratings had been previously examined by obtaining information from on-site interviews at eight southeastern Wisconsin lakes (46). Recreators were asked to rate lake water quality on a 0-23 scale such as that used by the LCI. The effectiveness of the LCI in predicting the public's perception of water quality was tested by regressing the average subjective rating $(\bar{R})$ of all recreators for each lake on the corresponding LCI for that lake. The results of this were encouraging, yielding the equation:

$$\ln R = 1.948 + \underset{(3.37)}{.364LCI} \qquad R^2 = .69 \qquad (8.11)$$

With this equation and a limnologist's estimates of the changes in LCI that would take place with and without the project, the recreationist's subjective perception of this change could be predicted.

Encouraged by the results of this previous study, questions regarding users' water quality perceptions were included as part of a random statewide telephone survey of Wisconsin households. Each respondent was asked to rate the water quality of the lake in question on the same 0-23 scale. This survey provided a cross-section sample of 723 observations among 243 Wisconsin lakes.

Attempts to duplicate the pretest results, though, proved unsuccessful as indicated by initial regressions' insignificant estimators and low coefficients of determination, suggesting that the LCI was not very effective in "explaining" the public's perception of water quality.

These results may be attributable to the different methods used in gathering information. In the previous research, responses were obtained by on-site interviews, whereas, the statewide sample was gathered through a telephone survey of a representative sample. This survey was conducted in October and November of 1978 and questioned respondents about their recreational activities between Labor Day 1977 to Labor Day 1978. Therefore, it is possible that the telephone survey technique introduces a recall factor bias where the respondent, being distant in space and time from the lake, cannot give as accurate a rating as he/she could have if they had been interviewed at the site. Another explanation may be that the telephone interview itself is inappropriate for a rating on a 23 point scale.

As indicated above, the most desirable procedure for estimating the benefits of water quality change is having a recreation demand model which includes a user's subjective water quality variable, and a link between this variable and a measurable, objective water quality variable, as used by the natural scientists, that will allow predication of change in the subjective variable. The next most desirable arrangement, that will still allow for an ex ante analysis, would be to use the objective water quality variable directly in the demand equation.

This latter approach requires a few observations on a large cross-section of many lakes of differing degrees of water quality, thereby allowing for a determination of the correlation between differing numbers of trips and water quality. In the current analysis this condition is satisfied by the statewide sample which included 243 lakes with typically one, two or three observations at each. In the earlier study the data were gathered at only eight lakes with many observations of each (2). Under these circumstances it was imperative that the individual's subjective water quality ratings rather than the LCI be used to determine the correlation between visits and water quality.

The Statistical Model

The general form of the model used to estimate water quality benefits is that employed by Bouwes and Schneider:

$$T_{ij} = \alpha + \sum_{k=1}^{n} \beta_k X_{ijk} + e_{ij}, \qquad (8.12)$$

where T_{ij} is the number of trips by decision-making unit i to lake j, X_{ijk} is the error term (2). The primary objective is to estimate a statistical demand curve with reliable estimates of the structural variables --particularly those of the cost variable from which the resource value is derived, and the water quality variable which is used to determine the economic significance of a change in water quality.

The initial general model included a set of regressions deemed to be consistent with economic theory and findings from previous recreation demand studies. Daytrips were hypothesized to be a function of the already mentioned round-trip travel costs and water quality variable as well as other variables deemed pertinent. Travel time is considered to be a cost of recreation and was included. Family income was included to account for the income effect on the decision maker. Tastes and preferences for related activities were represented by number of trips to all lakes visited.

The number of other lakes visited was used to reflect substitutes; this choice is based on the assumption that it is only the lakes that the recreator is aware of that constitute the relevant substitutes in his choice set. Recognizing that other site amenities distinguish sites, other variables reflecting water quality, lake size, availability of facilities, etc., were included.

Various functional forms were attempted in the estimation of the demand relationship --linear, linear in reciprocal, quadratic, semi-log, inverse semi-log, double log and translog. Each was run with the variables specified in the general model. When each of the functional forms of the general models was run, a plot of residuals against predicted values suggested that heteroscedasticity might be present. This was adjusted for in the manner proposed by Glejser (15). Once the data was properly weighted to deal with the heteroscedasticity the models were run again and variables were eliminated via F-tests to determine if their inclusion produced a significant difference.

Regressions based upon the entire statewide sample did not produce a significant demand equation. Since Northern Wisconsin lakes possess a considerably higher level of water quality, as determined by the Lake Classification Index, it was suspected that northern lake recreators might constitute a different population than southern lake users. Consequently, the state sample was divided into Northern and Southern counties and the regression analysis repeated. This effort provided statistically significant results that are reported below. Also, this sub-sample choice had intuitive appeal as the Shadow Lake is a northern lake used exclusively by daytrippers.

As indicated the data is based on individual observations. One of the justifications for utilizing data based on individual observations is that it reduces the multicollinearity between the cost and time variables that are present when zone averages are used, thereby allowing the inclusion of both in the estimation of the demand curve. When zoned averages are used, time is typically omitted. This produces a cost coefficient having too great a magnitude and hence an underevaluation of the resource. However, for the case at hand the use of individual observations did not alleviate the problem of multicollinearity. Consequently, it was necessary to compensate for this problem. This problem can be addressed by either omitting one of the variables, which then produces a biased estimator for the remaining variable, or by constructing a composite variable which would account for the presence of both variables. This latter alternative is consistent with economic theory that prescribes determining a value for travel time and adding this to actual travel costs. In other words, costs are presented as:

$$C_{ij}^{\lambda} = C_{ij} + \delta_i t_{ij} \tag{8.13}$$

where C_{ij}^{λ} is equal to total trip costs for individual i to lake j, C_{ij} is equal to round-trip travel costs, δ_i is the opportunity cost of time for decisionmaking unit i, and t_{ij} is round-trip travel time to lake j.

In order to utilize this form of the cost variable it is necessary to determine the appropriate value for δ_i, that is, what is the relevant opportunity cost of time. Cesario suggests that the value of time with respect to nonwork travel is between one-fourth and one-half of the wage rate (2). The former value was selected in an effort to maintain conservative benefit estimates. [7/] The opportunity value of time was determined from the reported income figures which were reduced to an hourly rate and applied to the round-trip travel time. [8/] The final estimated demand curve for visits is:

$$\underset{}{T_o} = \underset{(2.84)}{16.1651} - \underset{(2.18)}{3.1533} \ln C^{\lambda} - \underset{(1.77)}{5.4242} \ln LCI + \underset{(1.83)}{.3312} Y \quad n = 52 \qquad (8.15)$$

where T_o is the number of visits for the year, C^{λ} is the travel cost per trip plus the opportunity cost of travel time, LCI is the lake classification index, and Y is the recreator's income.

Economic Benefits Under Current and Alternative Water Quality Conditions

To estimate the flow of benefits attributable to the project it is necessary to estimate those benefits that would accrue each year with the project and the loss of benefits that would occur without the project -- the sum of these represents the relevant benefits. To accomplish this a two-step evaluation process is employed. This approach requires applying the derived statistical demand curve to each individual observation obtained at the site to be evaluated, and using the observed cost and visit data to reflect behavior at zero additional site cost. This is then used to estimate an aggregate demand curve for the total recreation experience from which the resource value is estimated. For example, by introducing a change in the costs term, c, into equation (8.14) the estimate of visits becomes:

$$T_c = 16.1651 - 3.1533 \ln (C^{\lambda}+c) - 5.4242 \ln LCI + .3312 Y \qquad (8.15)$$

Substituting equation (8.14) into equation (8.15) and simplifying yields:

$$T_c = T_o + 3.1533 (\ln C^{\lambda} - \ln(C^{\lambda} + c)). \qquad (8.16)$$

in water quality will modify recreation behavior. To determine the effect of a water quality change, the demand equation can be rewritten as:

$$T_o^* = T_o - 5.4242 \, (\ln \, (LCI + \ell) - \ln LCI) \qquad (8.19)$$

where T_o^* is the estimated number of trips demanded by decision-making unit i given a change in water quality as reflected by ℓ. Substituting T_o^* for T_o into equation (8.16) yields the desired results. Consumer surplus associated with a change in water quality, CS_i^*, can now be estimated by:

$$CS_i^* = \int_o^{c_o} [T_o^* + 3.1533 \, (\ln C^\lambda - \ln \, (C^\lambda + c))] \, dc \qquad (8.20)$$

Total resource value with the change in water quality is determined by:

$$RV^* = \sum_{i=1}^{n} \Psi \, CS_i \qquad (8.21)$$

The resulting change in resource value under various levels of water quality can be determined by calculating the difference between the initial resource value, as determined by equation (8.18), and that occurring after the water quality change, as calculated by equation (8.21), i.e.,

$$\Delta RV = |RV^* - RV| \qquad (8.22)$$

The absolute value is required as a decline in WQ will create a situation where $RV = RV^*$, a negative value. However, these are to be interpreted as benefits as these are costs avoided by the project.

To perform _ex ante_ analysis of an expected water quality change it is necessary to (a) establish the resource value with current water quality conditions; and (b) determine the impact associated with a change in water quality both with and without the project.

This can be achieved given the procedures described above and a limnologist's estimated schedule of water quality changes both with and without the project.

LP Farm Impact Model

Since phosphorous was considered to be the limiting factor in the White Clay Lake eutrophication process, it was determined that the lake stabilization project efforts should be directed to controlling this nutrient at its source. Given the pervasiveness of the dairy farms in the watershed it was felt that the resolution of this problem would be best handled by the instatllation of manure storage facilities and modification of crop management practices to be consistent with such facilities.

The impacts of adopting this form of nonpoint source pollution control technique extends beyond the single accounting cost of this facility. The farm enterprise will find it necessary to reallocate its capital and human resources, and it will possibly experience reduced fertilizer costs due to increased nutrient retention, and perhaps a change in crop output. Consequently, it is necessary to do more than merely examine the capital costs of the manure storage facility to determine total farm impact -- it is necessary to observe the farm operation with the facility in operation. This of course is not possible within the time frame of this study. Therefore, some means had to be devised to simulate the farm enterprise operation in order to estimate the farm impacts.

To accomplish this, a linear program (LP) model of a dairy farm operation was used to simulate the impact on profitability that would result from the adoption of manure storage facility. The model was further expanded to examine how a revenue-maximizing farmer might adjust to varying subsidy rates, cost-sharing rules, and erosion control legislation.

A linear programming optimization procedure is used to identify the combination of activities which maximize annual farm income (or annual pretax earnings) subject to the resource constraints of the farm. The objective function is defined to be the sum of annual farm receipts, e.g., from milk, cull cattle, etc., less the sum of annual out-of-pocket costs. In this model, we assume that all activities conducted on a dairy farm are characterized by constant returns to scale, and all non-land resources are freely mobile within the farm.

Details of the farm resource limits, and the set of farming activities were made on the basis of interviews with a northern Wisconsin farmer. This primary information source was supplemented by agricultural research publications and by assumptions on the design of public policy.

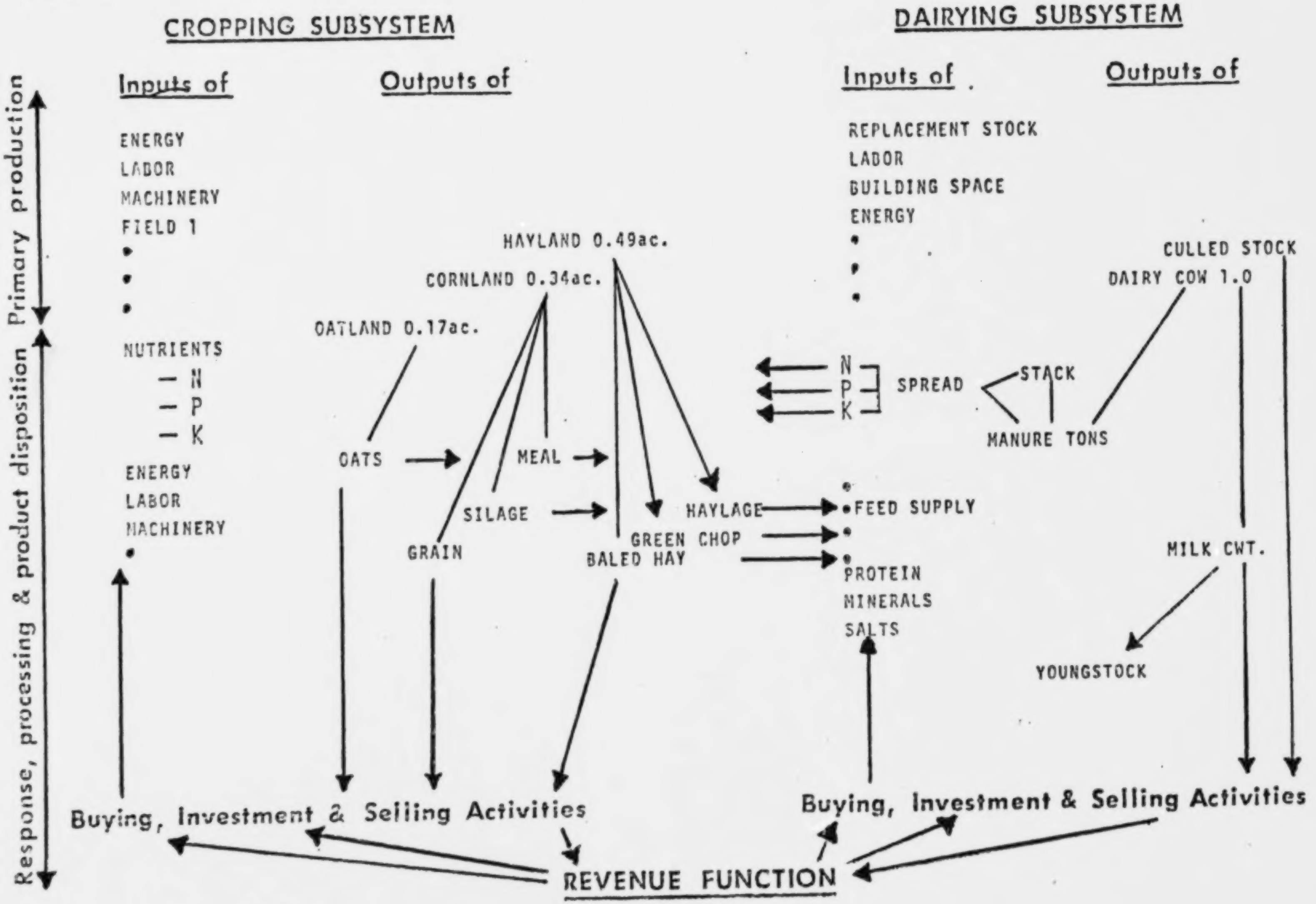
Farm activities transfer farm resources into farm outputs. The LP model, as illustrated in Figure 8.3, used to simulate the farm activities may be viewed as an ensemble of three interacting subsystems.

The Cropping Submodel

This model described how labor, machinery, land and fertilizer combine to produce crops. The cropping submodel contains seven alternative crop rotations. Each rotation requires a mix of inputs to produce specified quantities of crop outputs. The inputs include acres of land, tons of soil loss, kilowatts of energy, and hours of machinery and labor. The output is expressed as acres of cornland, oatland, and hayland.

The input-output relationship are based on farm interviews, with the exception of the soil loss input, which is computed using the Universal Soil Loss Equation (71). A constraint can be placed on total yearly soil loss. However, no limit was included in this analysis.

Figure 8.3--Production Interdependencies in a Mixed Crop-Livestock System


CROPPING SUBSYSTEM
DAIRYING SUBSYSTEM
Inputs of
Outputs of
Inputs of
Outputs of
Primary production
Response, processing & product disposition
ENERGY
LABOR
MACHINERY
FIELD 1
NUTRIENTS
— N
— P
— K
ENERGY
LABOR
MACHINERY
HAYLAND 0.49ac.
CORNLAND 0.34ac.
OATLAND 0.17ac.
OATS
MEAL
SILAGE
GRAIN
HAYLAGE
GREEN CHOP
BALED HAY
REPLACEMENT STOCK
LABOR
BUILDING SPACE
ENERGY
N
P
K
SPREAD
STACK
MANURE TONS
FEED SUPPLY
PROTEIN
MINERALS
SALTS
CULLED STOCK
DAIRY COW 1.0
MILK CWT.
YOUNGSTOCK
Buying, Investment & Selling Activities
Buying, Investment & Selling Activities
REVENUE FUNCTION

Source: (47)

The crop-producing process combines cropland acreage with nitrogen, phosphorus and potassium -- producing grain and forage (crop yield). Research listing the fertilization levels required to produce a given yield in Wisconsin while maintaining soil quality, is used as a guide for designing this section of the cropping model (62). It is assumed there are two sources of crop nutrients -- manure and commercial fertilizer. The two are interchangeable, except that a "starter" application of commercial nitrogen is required on corn. In addition, alfalfa is credited with nitrogen production.

Crops are often sold, but this option is not included in the program because this does not reflect the practice of the representative farm. Instead, all products raised on the farm are fed to livestock or stored for the future.

The Dairying Submodel

This submodel husbands cattle and replacement stock for milk production and animal sales. Corn, oats, and hay are mixed with feed supplements to form rations for the dairy herd.

There are four alternative combinations of forage and concentrate, which yield three levels of milk and manure production. Milk is sold and manure is used as an input in the cropping submodel.

In the dairying submodel, four methods are used to raise replacement stock. Each method requires an identical set of the following inputs: veterinary, labor, heifer barn space, breeding, and other livestock services. The four replacement-raising activities are distinguished from one another solely on the basis of how forage and grain requirements are satisfied.

Outputs of the replacement-raising activities include: revenue from sales of culled heifers; replacement stock for the dairy herd; and manure. To maintain a dairy herd of 80 cows --equal to the size of the interviewee's herd and which fully uses available barn space -- the size of the replacement herd must be 90 heifers. The latter figure is used by assuming a heifer culling rate of 12 percent, a cow-culling rate of 40 percent, and average age at first freshening of 26 months, and mortality rates for the following age groups: manure cows -- 2 percent; 12-24 months --1 percent; 3-12 months -- 2 percent, and 0-3 months --15 percent. The number of animals in the replacement herd, then, must be 12 percent more than the numbers of animals in the dairy herd (26).

Raising and milking dairy cows is similar to replacement-raising activities. Estimates of per cow livestock costs (expressed in liquidity terms), and yearly man-hours are included as inputs in each of the optional milking methods. The same source is consulted for the specification of a liquidity output, which results from the sale of culled dairy stock, for each activity. The size of that output depends on the assumptions that 40 percent of the dairy herd is culled annually, and that death loss claims 2 percent of the herd.

Any of the four rations can be used to produce 140 CWT of milk and 21 tons of manure per year from each cow. The farmer can also choose between a set of four rations to produce 12,000 pounds of milk and 18 tons of manure per year. Like the replacement rations, the milking rations are distinguished from one another by the way in which forage and grain requirements are met. Storage capacity sufficient to hold a year's supply of each type of grain and fiber must be provided, either by drawing on the farm's resources or by building such facilities. Similarly, each cow uses a certain amount of barn space.

The Financing Submodel

This submodel incorporates cash-flow considerations and long-term investment opportunities into the model. It is assumed that the farm must maintain a certain level of cash reserves at all times. Cash balances accumulate by marketing milk and surplus livestock. Input purchases are a drain on farm liquidity. Long-term investments can be financed by ten-year loans which carry an annual interest charge of 9.5 percent. Loan payments are deducted from gross farm income.

The farmer in the model must choose one of four manure management options. The cost and input requirements, and the amounts of nitrogen, phosphorus, and potassium made available to crops from a ton of manure handled by each method is shown in Table 8.1. These options are referred to as A, B, C or D. Under system A, manure is spread daily. This is the option used by the interviewed farmer as well as by his neighbors. In the other three options, manure is stored until fall, when it is disced into the fields: systems B, C, and D are distinguished from one another on three bases. First, each uses a unique type of storage capacity. Second, each requires different amounts of variable inputs (labor and machinery time, and energy) to store and spread a given amount of manure. Third, each delivers different quantities of nutrients to the soil from a unit of manure.

There are three activities corresponding to each management system. The first activity uses a loan to purchase the equipment and storage capacity required for an option. The amount of money needed to purchase a given collection of machinery and storage capacity must be large enough to handle the dairy herd's constant yearly manure output. The second activity uses machinery, labor, and energy to store manure. The third activity uses inputs

Table 8-1--Description of Manure Management Options, Wisconsin Dairy Farm, White Clay Lake Region, 1977

Option[1/]	Additional Required Capital Expenditures	Investment Cost $	Per Ton Input Requirements[b/]			Per Ton Nutrient Delivery[c/]		
			Labor (hrs)	Machinery (hrs)	Energy (hrs)	N (lbs)	P (lbs)	K (lbs)
A	None	0[d/]	0.23	0.17	0.00	3.72	3.80	7.45
B	Spreader Piston Pump Covered Concrete Storage	38,217[d/]	0.15	0.10	0.88	8.95	3.80	7.45
C	Spreader Stack Plank Storage	21,870[d/]	0.20	0.10	0.60	7.22	3.80	7.45
D	Spreader Piston Pump Earthen Storage	22,479[d/]	0.15	0.10	0.88	6.33	4.00	7.90

a/Option A consists of the present practice of daily spreading and, consequently requires no additional investment. Options B, C, D represent alternatives to daily spreading; these systems are described in (68).

b/Source (68) farm interviews.

c/Source: (68); (62).

d/Investment cost for an option is the cost of all equipment not already on the farm required to implement the option.

to spread manure, thereby supplying the cropping subsystem with nitrogen, phosphorus, and potassium.

Each system's capital cost equals the cost of all machinery and storage capacity which is needed for that system and which is not already in place on the farm. The daily spreading method (option A) which was initially employed on the representative farm, requires no investment. On the other hand, the other three options require purchasing capital items listed in Table 8.1

While management methods B, C, and D require higher capital and energy costs than option A, these systems require less machine and labor time to handle a ton of manure. Additionally, when option B, C, or D is used, more nutrients are obtained from a ton of manure than is the case where option A is used. A major reason for this increased nutrient delivery is that use of a storage facility allows a farmer to hold manure until that time of the year (during fall plowing, for instance) when manure can be better incorporated into the soil. When viewing option A's delivery, winter weather conditions and/or the presence of crops in the fields preclude the farmer from discing manure into the soil during most of the year.

As indicated, most farms in our study previously used manure handling option A. Therefore, status quo income is defined as the level of farm net income obtained when that system is used. Annual farm income was calculated using the LP optimization procedure, which chooses the mix of activities which maximizes prefax farm income subject to the farm's resource limitations.

CHAPTER 9

WAUPACA ECONOMIC EVALUATION

To properly estimate the economic impacts associated with a project there are several issues that must be determined, viz., what is the relevant period of analysis, and what is the proper discount rate?

According to the Water Resources Council's Principles and Standards, the period of analysis should be the lesser of: (1) the period of time over which the project will serve a useful purpose; or (2) the period of time when further discounting of beneficial and adverse effects will have no appreciable results on design (63). Since the property value model is specified in such a fashion that expected future benefits (costs) are capitalized in the property value at the time of a water quality change, then the appropriate time period is that in which something either positive or negative occurs either with or without the project that would impact the affected property values. Thus, when estimating impacts using the property value impact model the relevant time period, as determined by water quality experts, is 34 years.

In the estimation of recreational benefits the relevant time period is 50 years. When using the recreation model it is necessary to estimate and discount each year's impact. Consequently, it would be necessary to invoke the second condition specified in the Principles and Standards, e.g., at 50 years in the future a dollar discounted at 8 percent is only worth 2 cents.

In order to determine the economic viability of a particular project, one must reduce the time stream of costs and benefits to a single number. This aggregation is accomplished by computing the net present value of a project, and as indicated above, the rate of discount is a crucial parameter in this calculation. Theoretically, the correct discount rate is that rate which, when applied to future costs and benefits, yields their actual present social values. In other words, the proper rate is the rate at which society as a whole is willing to trade off present for future costs and benefits. There are several schools of thought regarding how one translates this definition into the appropriate, operational discount rate. Two measures of the discount rate that normally reflect the extremes are the opportunity cost of capital and the social time preference. Both of these rates will be employed to provide us with a sensitivity analysis on the impact of alternative interest rates.

The opportunity cost of capital reflects the value of the productivity that would have occurred had the resources not been taken out of the private sector of the economy by the government for the project. The cost of capital is affected not only by this productivity consideration but also by the degree of risk involved since a lender would charge a higher rate of interest to those less likely to repay. The prime lending rate is perhaps the best indicator of the current opportunity cost of capital. A rate of 15 percent was selected to reflect the higher costs of capital that now exist in todays financial markets.

The alternative viewpoint states that the government provides an intergenerational transfer of benefits. It acts as a trustee of the future. Thus, in evaluating public investment projects the government imposes a lower discount rate to provide for future generations. This viewpoint also questions some of the assumptions on which the previous approach is built. The most questionable assumption is that a government decision to implement a project causes a transfer of funds from the private to the public sector equal to the cost of the project. In the immensely complicated government budgetary process, the current appropriation of each agency is determined in large measure by its previous appropriation, current government fiscal and monetary policy and the administration goals. Thus, a specific project may have little or no effect on the size of the allocated budget. Furthermore, since the size of the total government budget is dictated, at the margin, by broad economic policy objectives, more for one agency necessarily means less for another. Consequently, a project is in direct competition for funds with alternative projects of the same agency and indirectly with projects of other agencies. Thus, the base of reference for the analysis of a project should be the alternative use of funds within the government sector, not funds within the private sector. This line of thinking supports a lower social discount rate than that of the opportunity cost of capital position. Accordingly, the Principles and Standards specifies that the official discount rate for water related projects is set by the Water Resources Council, which for fiscal year 1980 set the rate at 7 1/8 percent (63).

In addition to these considerations project impacts will be measured by estimating the project condition with and without the project. This is necessary as changes will occur in the absence of the project and these must be taken into account.

Property Value Impacts

The application of the property value impact model presented earlier requires the following information:

(a) Annual estimates by a water quality expert of changes expected in the seven water quality parameters both with and without the project (provided in Tables 3.3 and 3.4);

(b) The effective time period of the analysis (34 years - see discussion above);

(c) The percentage of shoreline that is accessible to the public;

(d) The maximum distance-from-the-lake for the residential area considered to be impacted by the park;

(e) The number of homogenous zones within the impact area;

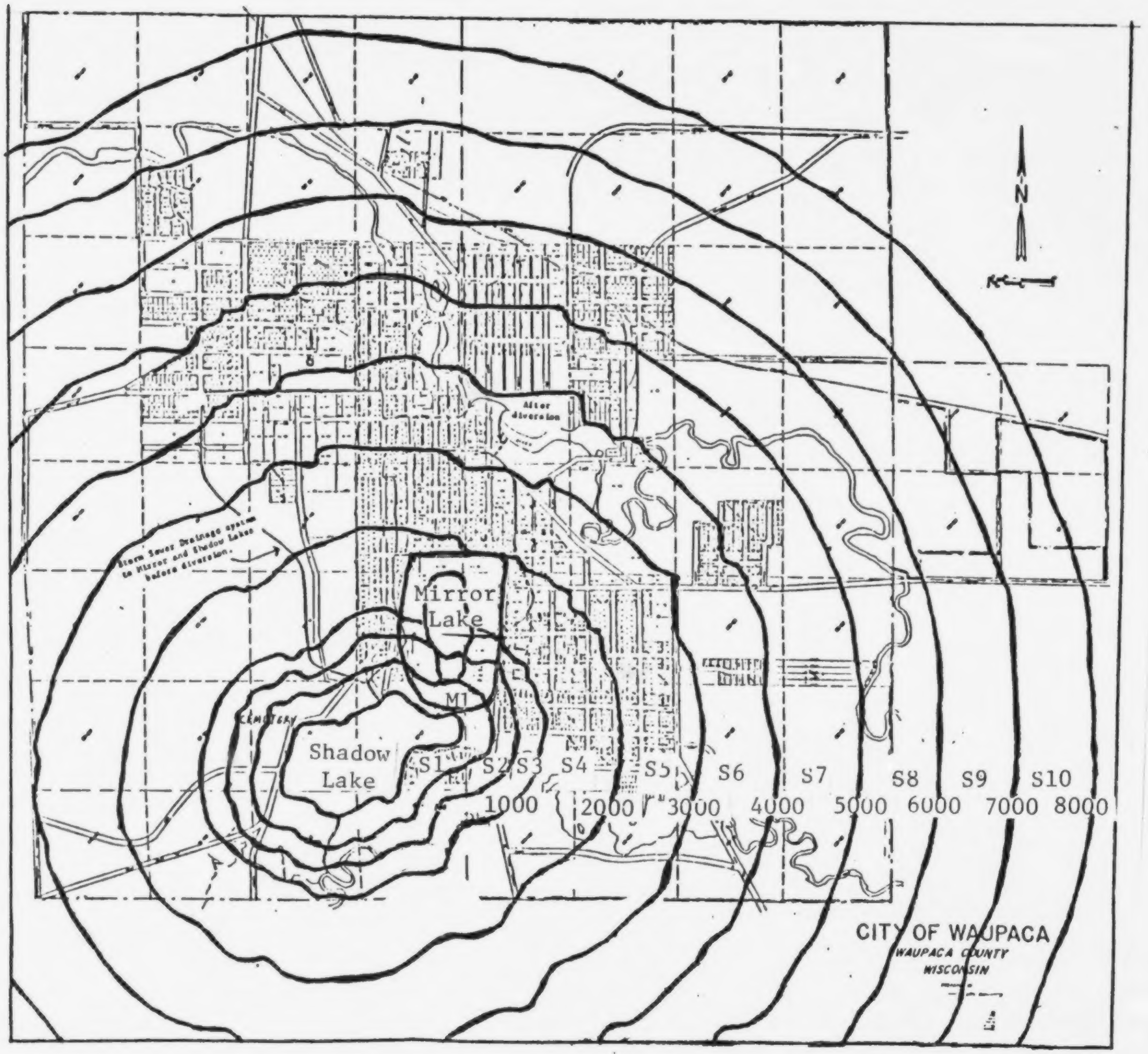
(f) The property development growth rate; and

(g) The property values for residential properties within the impacted area and their distance from the lake.

Since (a) and (b) have already been discussed the following will be directed to (c) thru (g).

Equation (8.4) specifies that the percentage change in property value is a function, among other things, of the property's straight line distance from the lake, i.e., $\Delta P\%_d = b_o + b_1 (1/DW_d)$. In order to avoid performing this calculation for each residential property, the total area to be impacted by the project for each lake has been divided into distance-from-the-water zones (d), as indicated on Map 9.1. Use of the simple step function, where each step is evaluated on the basis of the average distance to each distance-from-the-water zone, offers an operationally useful and accurate approximation of the continuous function's integration. This approach assumes that change in $\Delta P\%$ will be calculated for each distance zone d. Since Mirror Lake is bordered almost entirely by private homes and has very limited public access and use of the lake, the beneficiaries

Map 1--Distance from the Water Zones


N
After diversion
Storm Sewer Drainage system to Mirror and Shadow Lakes before diversion.
Mirror Lake
M1
Cemetery
Shadow Lake
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
1000
2000
3000
4000
5000
6000
7000
8000
CITY OF WAUPACA
WAUPACA COUNTY
WISCONSIN

of the improvements in water quality for that lake were restricted to only those residential properties that border on the lake. Consequently, only one distance zone (M1 on the map) was used for Mirror Lake. Shadow Lake, on the other hand, has extensive public access and facilities for varied public use, so its impact area was assumed to be all residential home owners in the city of Waupaca. Consequently, ten distance-from-the-water zones (S1-S10 on the map) were used.

The benefit calculation for a given year (in this case the equation pertains to residential properties impacted by Shadow Lake) is the following:

$$\mathrm{RPB} = \sum_{d=1}^{10} \mathrm{INCRAP\%}_d * \mathrm{TRPV}_d * (1+\mathrm{GR}_d)^i \qquad (9.1)$$

where RPB represents residential property benefits; $\mathrm{INCRAP\%}_d$ represents the incremental percentage change in the value of properties in distance zone d for that year; TRPV_d is the sum total of the residential property values for zone d, and $(1 + \mathrm{GR}_d)^i$ represents an annual growth factor to account for the expected future development of vacant land in that zone. The growth factor, GR, represents the projected percentage change in population in Waupaca between 1977 and 2000 (64). It is assumed that the increase in residential homes is proportional to the projected percentage increase in population. Furthermore, it is assumed that the twenty-three year projection of 22 percent population increase will apply to the thirty-four year period of analysis used for this project (1976-2011) (64). This does not seem to be an unreasonable assumption once a leveling off effect is taken into consideration.

Since vacant land for residential development is primarily available on the northern and western parts of the city, only those distance zones which contain portions of this vacant land will have a growth factor. Consequently, only the distance zones S4-S10 contain a non-zero GR_d. In order that the total growth rate over the thirty-four year period be equal to 22 percent, the annual growth rate is estimated to equal .0058. For the i^{th} year the total growth rate would be $(1.0058)^i$.

Theoretically, the appropriate measure of residential property values is the market value. The problem with using market values is that in a given distance-from-the-water zone the average market value of properties sold that year may not be an accurate measure of the actual average value of all the properties there, which would necessarily lead to an inaccurate estimation of the property benefits for that zone. Consequently, an adjusted assessed value of residential property for the year 1976 was used. The adjustment factor was determined by the inverse of the average assessment ratio:

$$\text{Average Assessment Ratio} = \left[\sum_{i=1}^{N} \left(\frac{\text{assessed value}_i}{\text{market value}_i} \right) \right] / N \qquad (9.2)$$

where N equals the number of properties sold in zone d in 1976. The adjusted assessment value total (i.e., the sum of the assessed value for zone d multiplied by the inverse of the average assessment ratio) serves as a close approximation of the total market value of the residential properties in that zone. These values are provided in Table 9.1 for the city of Waupaca.

Table 9.1--Waupaca Property Values by Distance-From-Water Zones, 1976

Lake	Distance-From-Water Zone (See Map 1)	Max. and Min. Distance Range of Zone (feet)	Average Distance of Zone (feet)	Property Value Zone Totals	Annual Growth Factor (GRd)
Mirror	M1	0-400	200	$1,403,500	-0-
Shadow	S1	0-400	200	868,600	-0-
Shadow	S2	400-700	550	453,400	-0-
Shadow	S3	700-1,000	850	1,088,400	-0-
Shadow	S4	1,000-2,000	1,500	4,450,560	.0058
Shadow	S5	2,000-3,000	2,500	7,011,700	.0058
Shadow	S6	3,000-4,000	3,500	5,343,540	.0058
Shadow	S7	4,000-5,000	4,500	5,902,300	.0058
Shadow	S8	5,000-6,000	5,500	1,892,880	.0058
Shadow	S9	6,000-7,000	6,500	818,900	.0058
Shadow	S10	7,000-8,000	7,500	282,000	.0058

By using the annual $PWQI_{Exp}$ ratings developed on a with or without project basis in Tables 3.3 and 3.4 and equations (3.2) (8.4), (8.6), and (8.8) from the empirical model, the total annual percentage change in property values ($\Delta P\%$) can be calculated for the two lakes. Since property value impacts are capitalized in the year a water quality change takes place, it is necessary to determine the annual incremental increase. The annual incremental percentage change in property values ($INCR\Delta P\%$) for year (i) is calculated in the following manner:

$$INCR\Delta P\%_i = \Delta P\%_i - \Delta P\%_{i-1} \qquad (9.3)$$

The total and incremental calculations for Mirror Lake are presented in Table 9.2. The total and incremental calculations for Shadow Lake are presented in Tables 9.3 and 9.4, respectively. For Mirror Lake the changes in property values occurred in the second, third, fourth and twenty-fifth year of the project. For Shadow Lake the changes occurred in the third, twenty-fifth and thirty-fourth year of the project. For both lakes the amount of change decreased through time, and for Shadow Lake the amount of change also decreased with increasing distance-from-the-lake as expected.

In Tables 9.5 and 9.6 the annual $INCR\Delta P\%$ is multiplied by the appropriate zone total of property values to give in dollar terms the incremental, annual increase in property values for each lake.

In Tables 9.7 these incremental, annual increases in property values are discounted back to 1977 using both the 7-1/8% and the 15% discount rates and the sum to give the total discounted property value benefits expected to occur for each lake as a consequence of having undertaken the

Table 9.2--Total and Incremental Annual Percentage Change in Property Values for Mirror Lake

Year	a/ $PWQI_{Exp}$	b/ $PWQI_{Res}$	c/ b_1	d/ b_o	e/ ΔP% for M1	INCR ΔP% M1
1977	7.77	0.0	0.0	0.0	0.0	0.0
1978	29.76	4.50188	4097.8247	-10.244561	10.244	10.244
1979	43.65	10.93295	6340.7752	-15,851938	15.852	5.608
2001	61.80	19.33640	8394.2205	-20.985551	20.986	5.134

a/ $PWQI_{Exp}$ is taken from Table 3.3

b/ $PWQI_{Res}$ is calculated according to equation(3.2): $PWQI_{Res} = -24.778 + .463 (PWQI_{Exp}) = 15.501 (PA)$ where PA = 1

c/ b_1 is calculated according to equation(8.6):

$$b_1 = e^{6.398}(PWQI_{Res}).492\ e^{1.180}(WBT\ Lake)$$

d/ b_o is calculated according to equation(8.8):

$$b_o = -b_1(DW_{max}) \text{ where } DW_{max} = 400$$

e/ ΔP% is calculated according to equation(8.4):

$\Delta P\% = b_o + b_1\ (1/\overline{DW}_j)$ for the one distance zone;

$\overline{DW}_j$ is the average distance from the lake to the zone.

Table 9.3--Total Annual Percentage Change in Property Values for Shadow Lake

Year	a/ $PWQI_{Exp}$	b/ $PWQI_{Res}$	c/ b_1	d/ b_o	e/ ΔP% for zone S1	ΔP% for zone S2	ΔP% for zone S3	ΔP% for zone S4	ΔP% for zone S5	ΔP% for zone S6	ΔP% for zone S7	ΔP% for zone S8	ΔP% for zone S9	ΔP% for zone S10
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1979	12.3	11.9189	6615.9432	-.8269929	32.253	11.202	6.956	3.504	1.819	1.063	0.643	0.376	0.191	0.055
2001	54.19	31.31397	10641.105	-1.3301381	51.875	18.017	11.189	5.764	2.926	1.71	1.034	0.605	0.307	0.089
2010	60.64	34.30032	11128.849	-1.3911061	54.253	18.843	11.702	6.028	3.06	1.788	1.082	0.632	0.321	0.093

a/ $PWQI_{Exp}$ is taken from Table 3.4.

b/ $PWQI_{Res}$ is calculated according to equation (3.2): $PWQI_{Res} = 024.778 + 0.463\ (PWQI_{Exp}) + 15.501\ (PA)$ where PA = 2

c/ b_1 is calculated according to equation (8.6): $b_1 = e^{6.398}(PWQI_{Res})^{0.492}e^{1.180}$ (WBT Lake)

d/ b_o is calculated according to equation (8.3): $b_o = -b_1\ (DW_{max})$ where $DW_{max} = 8{,}000$.

e/ ΔP% is calculated according to equation (8.4): $\Delta P\% = b_o + b_1\ (1/\overline{DW}_j)$ for each distance zone. $\overline{DW}_j$ is the average distance from the lake to each distance zone.

Table 9.4--Incremental ΔP% Calculations - Shadow Lake [a]

Year	INCR Δ P% S1	INCR Δ P% S2	INCR Δ P% S3	INCR Δ P% S4	INCR Δ P% S5	INCR Δ P% S6	INCR Δ P% S7	INCR Δ P% S8	INCR Δ P% S9	INCR Δ P% S10
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1979	32.253	11.202	6.956	3.584	1.819	1.063	0.643	0.376	0.191	0.055
2001	19.622	6.815	4.233	2.18	1.107	0.647	0.391	0.229	0.116	0.034
2010	2.378	0.826	0.513	0.264	0.134	0.078	0.048	0.027	0.014	0.004

[a] Incremental ΔP% figures are derived from ΔP% figures in Table 9.3, i.e.,

$$\mathrm{INCR}\Delta P\%_i = \Delta P\%_i - \Delta P\%_{i-1}.$$

Table 9.5--Incremental Annual Increase in Property Values - Mirror Lake

Year	a/ INCRΔP% for M1	b/ Property values by zone	Increase in Property value
1977	0.0	$1,493,500	$ 0
1978	.10244	1,403,500	143,774
1979	.05608	1,547,274	86,171
2001	.05134	1,634,045	83,891

a/ INCR P% for MI is taken from Table 9.2.

b/ Initial property value is taken from Table 9.1. Subsequent changes attributable to water quality impacts are then added.

Table 9.6--Incremental Annual Increase in Property Values - Shadow Lake

Zone and Year [a]	INCRΔP% for Zone ___ [b]	Property Value for Zone ___ [c]	Total Incremental Change for Zone ___ [d]
	---Percent---	---Dollars---	
Zone 1:			
1977	.00000	868,600	0
1979	.32253	868,600	280,150
2001	.19622	1,148,750	0
2010	.2378	1,374,158	32,677
Zone 2:			
1977	.00000	453,400	0
1979	.10202	453,400	50,790
2001	.68150	504,190	34,361
2010	.00826	538,551	4,448
Zone 3:			
1977	.00000	1,088,400	0
1979	.06456	1,088,400	75,709
2001	.04233	1,164,109	49,277
2010	.00513	1,213,386	6,225
Zone 4:			
1977	.00000	4,450,560	0
1979	.03584	4,502,336	161,364
2001	.02180	5,296,470	115,463
2010	.00264	5,767,404	15,226
Zone 5:			
1977	.00000	7.011,700	0
1979	.01819	7,093,272	129,026
2001	.01107	8,202,218	90,800
2010	.00134	8,837,725	11,843
Zone 6:			
1977	.00000	5,343,540	0
1979	.01063	5,405,705	57,463
2001	.00647	6,204,409	40,143
2010	.00078	6,654,711	5,191
Zone 7:			
1977	.00000	5,902,300	0
1979	.00643	5,970,965	38,393
2001	.00391	6,819,497	26,664
2010	.00048	7,295,836	3,502
Zone 8:			
1977	.00000	1,892,880	0
1979	.00376	1,914,901	7,200
2001	.00229	2,181,914	4,897
2010	.00027	2,330,225	629
Zone 9:			
1977	.00000	818,900	0
1979	.00191	828,427	1,582
2001	.00116	942,410	1,093
2010	.00014	1,005,403	141
Zone 10:			
1977	.00000	282,000	0
1979	.00055	285,280	157
2001	.00034	324,143	110
2010	.00004	345,544	14

---

[a] 1977 reflects initial water quality conditions and 1979, 2001, and 2010 are the years in which a water quality change occurs.

[b] INCRΔP% data taken from Table 9.3.

[c] Initial property values by zone are taken from Table 9.1. Subsequent changes attributable to water quality increases and growth are then added.

[d] Total incremental change in property values is the product of INCRΔP% and relevant property value for that zone.

Table 9.7--Discounted Incremental Annual Property Value Increases to 1977

Year	Mirror Lake		Shadow Lake	
	Discounted at 7-1/8%	Discounted at 15%	Discounted at 7-1/8%	Discounted at 15%
	---Dollars---			
1978	134,212	125,021	---	---
1979	75,612	65,608	698,718	606,267
2001	16,099	2,928	112,898	20,532
2010	---	---	8,261	791
Total	$225,923	$193,557	$819,877	$627,590

lake rehabilitation project. The total discounted property value increase for Mirror Lake is $225,923 and $193,557, using a 7-1/8 and 15 percent discount rate, respectively. For Shadow Lake, the total discounted property value increase using a 7-1/8 percent discount rate is $819,877 and $627,590 using a 15 percent discount rate. The total benefits are therefore $1,045,800 and $821,147 for the two discount rates.

Direct Project Costs

The direct monetary costs of the project includes the costs of storm sewer diversion, purchase and installation of the compressor for aeration, annual operating and maintenance costs for the compressor and alum treatment costs. In order to compare project costs with project benefits, the costs have been discounted to 1977. Using the 7-1/8 percent interest rate, the total project costs expressed in 1977 dollar terms are $439,872 and $469,650 when the 15 percent interest rate is used.

Equity

The foregoing analysis has revealed that benefits, as determined by the property value impact model, are in excess of the costs, whether discounted at 7-1/8 or 15 percent. Although this information does not provide a complete picture regarding project efficiency due to the omission of non-local recreational benefits, it does provide insight to the incidence of local benefits and costs.

Distributional equity refers to distribution of benefits and costs associated with a project. There are significant equity considerations involved with the Mirror-Shadow Lakes restoration project that are of interest. It is assumed here that the federal, state, and local cost shares have been appropriately determined and, therefore, only the distribution of the local cost share will be examined.

Local revenues were raised by levying a two-year 0.9 mill tax to provide funds to cover the 20 percent of the project costs. Consequently, each residential property owner paid for a portion of the project according to the before project property value, e.g., approximately $90 for a $50,000 home. However, the well-being that each residential property owner enjoys as a result of the project does not vary in the same manner as the amount of taxes each had to pay.

In the case at hand there exist two reasons for the discrepancy. First, the impact on property values diminishes as distance from the lake increases. This is demonstrated in Table 9.8 which compares the percent of project benefits received to percent of project costs paid by zone. In Zone 1 it is estimated that approximately 35 percent of the project benefits accrue, yet only 3 percent of the project costs were paid by property owners in this zone. Benefits accrued exceed costs paid, at a diminishing rate, through zones 1-4, and costs exceed benefits in zones 5-9. Consequently, the increases in well-being of residential property owners closer to the lake appears to come at the expense of the well-being of the property owners situated farther from the lake.

The second reason, and one probably unique to this case, is that Mirror Lake-front property owners enjoy both the benefits of water quality improvements made on that lake and those made on Shadow Lake, while other property owners enjoy only the benefits from improvements made on Shadow Lake. The reason for this is that public access on Mirror Lake is highly restricted but not so on Shadow Lake. The total discounted property value increases enjoyed exclusively by Mirror Lake-front property owners due to improvements made in the water quality on Mirror Lake is $225,923 and the

Table 9.8--Benefit and Cost Incidences for Waupaca Residential Property Owners to Shadow Lake Rehabilitation Project

Zone	Average Distance From-the-Water of Zone (Feet)	Residential Property Values 1976 Zone Totals (Dollars)	Project Benefits Received (Percent)	Project Costs Paid (Percent)
1	200	868,600	35.5	3.1
2	550	453,400	6.2	1.6
3	850	1,088,400	9.3	3.9
4	1,500	4,450,560	21.0	15.8
5	2,500	7,011,700	16.0	25.0
6	3,500	5,343,540	7.0	19.0
7	4,500	5,902,300	4.9	21.0
8	5,500	1,892,880	0.9	6.7
9	6,500	818,900	0.2	2.9
10	7,500	282,000	0.0	1.0
		TOTAL	100.0	100.0

total discounted property value increases enjoyed by Mirror Lake-front property owners due to improvements in the water quality on Shadow Lake is $105,950. Thus, approximately 31 percent of total project benefits are enjoyed by Mirror Lake-front property owners. It might be argued that this is an overestimation of benefits for Mirror Lake property owners as it is reasonable to assume they may not fully value the benefit flow from the enhancement of Shadow Lake because of the more accessible substitute they have in Mirror Lake. Unfortunately, there does not exist enough information to determine the extent of this bias. However, this does not refute the argument regarding the distribution of benefits and costs, only the degree of this distribution.

Since local revenues were raised through a two-year increase in the property tax mill rate, the percentage of local project costs born by the Mirror Lake-front property owners is equal to the sum of their assessed property values divided by the sum of all assessed property values for the City of Waupaca, which is considered the impact area for this project. The percentage of local costs born by the Mirror Lake-front property owners is approximately 5 percent.

The Mirror Lake-front property owners enjoy 31 percent of the total project benefits and bear only 5 percent of the local project costs. The increase in the well-being of these property owners appears to come at the expense of the other property owners.

Recreational Benefits

To estimate the recreational benefits the model presented earlier will be employed plus the water quality conditions information as represented by the LCI in Table 3.5.

The flow of benefits will vary considerably depending on the elasticity of the demand curve, the change in water quality, and number of users, and the discount rate used to discount benefits (costs). The first of these is dictated by the data and estimation procedure used and therefore will not be subject to change. The projections concerning water quality are based upon water quality experts judgments and are assumed correct. However, the last two factors, user number and discount rate, are subject to wide variations and require special consideration. This was accomplished through the use of sensitivity analysis.

User figures were available from previous Waupaca Recreation Department user counts. As one might expect these varied widely from year to year because of fluctuations in the weather. In 1978, the year following project completion had many rainy and overcast days which resulted in only 40,132 users. 1/ However, in 1968, a very hot summer, the user population was 76,026. 2/ These figures will form the relevant bounds for the sensitivity analysis.

The flow of benefits are spread over the entire life of the project. To compare this time stream of project benefits with the project costs, they must be discounted to their present value, as was done with the property value impacts.

The total recreational benefits attributable to water quality changes were estimated by the procedure outlined in Chapter 8. The annual with and without impacts over the 50-year duration of the project are presented in Tables 9.9 and 9.10 for the two user populations. The lowest estimate of total discounted recreational benefits based on 40,132 users and the 15 percent discount rate was $252,172 and the highest estimate based on 76,026 users and the 7-1/8 percent discount rate was $1,349,818. Since the

Table 9.9--Annual Recreation Benefits at Shadow Lake Based on 40,132 Visits

Year a/	With Project			Without Project			Total Benefits Discounted at b/	
	Changes in Consumer Surplus	Discounted at		Changes in Consumer Surplus	Discounted at			
		7-1/8%	15%		7-1/8%	15%	7-1/8%	15%
1977	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
1978	0	0	0	0	0	0	0	0
1979*	10,044	8,752	7,594	0	0	0	8,752	7,595
1980*	21,612	17,580	14,210	0	0	0	17,580	14,210
1981*	35,147	26,688	20,095	0	0	0	26,689	20,095
1982*	51,230	36,313	25,470	0	0	0	36,314	25,470
1983	51,230	33,898	22,148	0	0	0	33,898	22,148
1984	51,230	31,643	19,259	0	0	0	31,644	19,259
1985	51,230	29,539	16,747	0	0	0	29,539	16,747
1986	51,230	27,574	14,562	0	0	0	27,574	14,563
1987	51,230	25,740	12,663	0	0	0	25,740	12,663
1988	51,230	24,028	11,011	0	0	0	24,028	11,011
1989	51,230	22,430	9,575	0	0	0	22,430	9,575
1990	51,230	20,938	8,326	0	0	0	20,938	8,326
1991	51,230	19,545	7,240	0	0	0	19,546	7,240
1992	51,230	18,245	6,295	0	0	0	18,246	9,296
1993	51,230	17,032	5,474	0	0	0	17,032	5,475
1994	51,230	15,899	4,760	0	0	0	15,899	4,761
1995	51,230	14,841	4,139	0	0	0	14,842	4,140
1996	51,230	13,854	3,599	0	0	0	13,855	3,600
1997	51,230	12,933	3,130	0	0	0	12,933	3,130
1998	51,230	12,073	2,721	0	0	0	12,073	2,722
1999*	51,230	11,270	2,366	16,557	3,642	765	15,715	3,131
2000*	51,230	10,520	2,058	29,800	6,121	1,198	16,641	3,256
2001*	51,230	9,820	1,789	40,881	7,836	1,427	17,656	3,216
2002*	51,230	9,168	1,556	50,393	4,018	1,532	18,186	3,088
2003	51,230	8,557	1,353	50,393	8,417	1,330	16,974	2,683
2004	51,230	7,988	1,176	50,393	7,857	1,154	15,845	2,335
2005	51,230	7,457	1,023	50,393	7,335	1,008	14,192	2,031
2006	51,230	6,961	889	50,393	6,847	877	13,808	1,766
2007	51,230	6,498	773	50,393	6,391	761	12,889	1,534
2008	51,230	6,066	672	50,393	5,967	660	12,033	1,332
2009*	51,230	5,662	585	53,433	5,905	609	11,567	1,194
2010*	51,230	5,286	508	58,734	6,060	581	11,346	1,089
2011	51,230	4,934	442	58,734	5,657	505	10,591	947
2012	51,230	4,606	384	58,734	5,281	441	9,887	825
2013	51,230	4,300	334	58,734	4,930	382	9,230	716
2014	51,230	4,014	290	58,734	4,602	335	8,616	625
2015	51,230	3,746	252	58,734	4,295	288	8,041	540
2016	51,230	3,498	219	58,734	4,011	253	7,509	472
2017	51,230	3,265	191	58,734	3,743	217	7,008	408
2018	51,230	3,048	166	58,734	3,494	188	6,542	354
2019	51,230	2,845	145	58,734	3,262	164	6,107	309
2020	51,230	2,655	126	58,734	3,044	147	5,699	273
2021	51,230	2.479	109	58,734	2.842	123	5,321	232
2022	51,230	2,314	95	58,734	2,653	112	4.967	207
2023	51,230	2,160	83	58,734	2,476	94	4,636	177
2024	51,230	2,017	72	58,734	2,312	82	4,329	154
2025	51,230	1,882	63	58,734	2,158	70	4,040	133
2026	51,230	1,757	54	58,734	2,014	65	3,771	119
	Total:	$574,335	236,810	Total:	138,170	15,373	713,298	252,172

a/Years in which water quality changes occur are denoted by an asterisk.

b/Total benefits are equal to the sum of the with project benefits and the without project benefits

Table 9.10--Annual Recreation Benefits at Shadow Lake Based on 76,026 Visits

Year a/	With Project			Without Project			Total Benefits	
	Changes in Consumer Surplus	Discounted at		Changes in Consumer Surplus	Discounted at		Discounted at b/	
		7-1/8%	15%		7-1/8%	15%	7-1/8%	15%
1977	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
1978	0	0	0	0	0	0	0	0
1979*	19,027	16,580	14,387	0	0	0	16,580	14,387
1980*	40,942	33,304	26,920	0	0	0	33,304	26,920
1981*	66,584	50,559	38,069	0	0	0	50,560	38,070
1982*	97,053	68,794	48,252	0	0	0	68,795	48,253
1983	97,053	64,219	41,958	0	0	0	64,219	41,959
1984	97,053	59,947	36,485	0	0	0	59,948	36,486
1985	97,053	55,960	31,726	0	0	0	55,961	31,727
1986	97,053	52,238	27,588	0	0	0	52,239	27,589
1987	97,053	48,764	23,990	0	0	0	48,764	23,990
1988	97,053	45,520	20,860	0	0	0	45,521	20,861
1989	97,053	42,493	18,139	0	0	0	42,493	18,140
1990	97,053	39,666	15,773	0	0	0	39,667	15,774
1991	97,053	37,028	13,716	0	0	0	37,029	13,716
1992	97,053	34,565	11,927	0	0	0	34,566	11,927
1993	97,053	32,266	10,371	0	0	0	32,267	10,372
1994	97,053	30,120	9,018	0	0	0	30,121	9.019
1995	97,053	28,117	7,842	0	0	0	28,117	7,842
1996	97,053	26,247	6,819	0	0	0	26,247	6,819
1997	97,053	24,501	5,929	0	0	0	24,501	5,930
1998	97,053	22,871	5,156	0	0	0	22,872	5,156
1999*	97,053	21,350	4,483	31,365	6,900	1,449	28,250	5,932
2000*	97,053	19,930	3,399	56,468	11,596	2,269	31,577	6,168
2001*	97,053	18,604	3,390	77,445	14,846	2,705	33,450	6.095
2002*	97,053	17,367	2,948	95,465	17,083	2,900	34,451	5,848
2003	97,053	16,212	2,563	95,465	15,947	2,522	32,159	5,086
2004	97.053	15,134	2,229	95,465	14,886	2,193	30,020	4.422
2005	97,053	14,127	1,938	95,465	13,896	1,907	28,024	3,846
2006	97,053	13.187	1,685	95.465	12,922	1,658	26,160	3,344
2007	97,053	12,310	1,465	95,465	12,109	1,442	24,420	2,908
2008	97,053	11,491	1,274	95,465	11,303	1,253	22,795	2,528
2009*	97,053	10,727	1,108	101,224	11,118	1,156	21,946	2,264
2010*	97,053	10.014	963	111,263	11,480	1,105	21,494	2,069
2011	97,053	9,348	838	111,263	10,717	961	20,065	1,799
2012	97,053	8,726	729	111,263	10,004	835	18,730	1,564
2013	97,053	8,146	633	111,263	9,338	726	17,485	1,360
2014	97,053	7,604	551	111,263	8,717	632	16,321	1.183
2015	97,053	7,098	479	111,263	8,138	549	15,235	1,028
2016	97,053	6,626	417	111,263	7,596	477	14,222	895
2017	97,053	6,186	362	111,263	7,091	415	13,277	777
2018	97,053	5,774	315	111,263	6,620	361	12,394	676
2019	97,053	5,390	273	111,263	6,179	314	11,569	588
2020	97,053	5,032	238	111,263	5,768	273	10,800	511
2021	97,053	4,697	207	111,263	5,385	239	10,082	444
2022	97,053	4,385	180	111,263	5,026	207	9,411	387
2023	97,053	4,093	157	111,263	4,692	180	8,795	337
2024	97,053	3,821	136	111,263	4,380	156	8,201	292
2025	97,053	3,567	118	111,263	4,088	136	7,656	254
2026	97,053	3,329	103	111,263	3,817	118	7,146	221
	Total:	$1,088,050	$448,625	Total:	$261,768	$29,128	$1,349,818	$ 477,764

a/Years in which water quality changes occur are denoted by an asterisk.

b/Total benefits are equal to the sum of the with project benefits and the without project benefits (costs avoided).

expected annual usage of Shadow Lake during each year of the project will probably vary between the two reported extremes, and assuming the social rate of discount most likely falls within the two discount rates used, the reported benefit figures represent the best possible confidence region attainable for recreational benefits.

The purpose of determining recreation benefits was two fold: (1) to estimate the benefits accruing to nonlocal recreators which would then be added to property value benefits and thereby completing the estimation of total project benefits; and (2) to allow examination of the hypothesis that property value impacts and recreation benefits should be similar in magnitude given the assumption that the former is comprised primarily of the latter.

With respect to the first issue the nonlocal recreation benefits, based on a 15 percent non-local usage rate, are estimated as follows: \$106,995 and \$37,825 when based on 40,132 users and discounted at 7-1/8 and 15 percent, respectively; and \$202,472 and \$71,665 when based on 76,026 users and discounted at 7-1/8 and 15 percent, respectively. Assuming that the range of recreators will reflect an average of the extremes one might expect the nonlocal recreation benefits to fall between \$154,734 or \$54,745, depending on the discount rate used.

When discounted at 7-1/8 percent, total property value impacts were estimated to be \$225,923 at Mirror Lake and \$819,877 at Shadow Lake. Because of limited public access to Mirror Lake, recreation benefits were only estimated for Shadow Lake; consequently, only the latter figure of \$819,877 in property value changes will be used for comparison purposes. As indicated, total recreational benefits range, depending on usage rate, from \$713,172 to \$1,349,818 with a 7-1/8 percent discount rate. Adjusting to exclude the assumed 15 percent nonlocal usage, and again assuming the average of the extreme usage rates, the probably average is $876,770. When compared with the estimate of discounted property value impacts of $819,877 a minimal difference is revealed.[10/] This is of particular interest given that the estimation procedures are so different. Consequently, this tends to lend credence to the estimation, as one method reinforces the level of acceptability of the other.

Project Efficiency

The efficiency issue examines whether the reallocation of resources to the project, e.g., those used for water pollution control provide benefits in excess of the value of the resources used. Ideally, one would wish to determine not only if the resources had been optimally allocated among alternative users, but also whether they are optimally allocated for a given project. This study does not provide an analysis that compares the flow of benefits of this project with possible alternative projects, or the determination of the optimal project scale. The analysis is restricted to an evaluation of a project that had been sanctioned by the political process which likely did not compare it economically with alternative projects. The absence of the necessary cost functions prohibit the determination of optimal project size.

One common approach for examining project efficiency is to express the impact in term of benefit-cost ratios. If the ratio is greater than one, the present value of discounted project benefits exceeds that of discounted project costs and the project has met at least a minimum standard of economic efficiency.

The total project benefits are equal to the property value impacts plus the benefits accruing to the non-local recreators. Total property value impacts are $1,045,800 and $821,147 when discounted at 7-1/8 and 15 percent, respectively. Total non-local recreation benefits associated with the average use rates are $154,734 and $54,745. Consequently, total project benefits are $1,200,534 and $875,892 for the 7-1/8 and 15 percent discount rates, respectively. Given the corresponding cost figures of $439,872 and $469,650 favorable ratios of benefits to costs are provided regardless of the discount rate used, i.e., 2.73 and 1.86. Therefore, it may be concluded from the foregoing analysis that the decision to undertake the lake rehabilitation project at Mirror and Shadow Lakes was an efficient one.

CHAPTER 10

WHITE CLAY LAKE ECONOMIC EVALUATION

The procedure for estimating project impacts of the White Clay Lake project are somewhat different from those employed for the Mirror and Shadow Lake evaluation. The primary reason for this is due to the agricultural setting. Consequently, a model that simulates the farm enterprise is employed to determine the impact of adopting water quality improvement practices. Changes in farm income due to the adoption of the project will reflect project impacts. Additional impacts will be realized as the water quality improvements in the lake will provide benefits that are not captured in the farm model. Therefore, the recreation model will also be used. Total project impacts is estimated by summing these two elements and, as was the case in the Waupaca analysis, benefit and costs will be calculated according to the period of time over which the project serves a useful purpose or when further discounting will have no appreciable effect. And a sensitivity analysis employing the 7-1/8 and 15 percent discount rate will be used. The with and without format is used in this case study as well.

Recreation Benefits

The White Clay Lake project was directed towards stabilization rather than rehabilitation. The effect of the project is shown in Table 4.14 where the Lake Condition Index with the project remains constant at a level of five. Without the project it was assumed that the water quality would steadily decrease until it stabilized at the low water quality level of sixteen. The user population was estimated to be at approximately 7,500. 11/ These recreators were comprised primarily of fisher persons.

The recreation benefits were estimated using this information and employing the evaluation technique described in Chapter 8. The results are presented in Table 10.1. The change in consumer surplus reflects the sum of the benefits attributable to the increase in water quality due to the project and the negative benefits that would occur in the absence of the project because of a decline in water quality. As was the practice in the preceeding chapter these changes in consumer surplus are discounted at both 7-1/8 and 15 percent, yielding $80,593 and $24,091, respectively.

Farm Income

There are two reasons to hypothesize an increase in farm income resulting from the adoption of one of the alternative manure storage facilities. First, all of the alternative manure storage techniques result in more nutrients being incorporated into the soil thereby improving soil quality and decreasing purchases of commerical fertilizer. Second, many of these management systems require fewer labor and machinery hours to handle a given quantity of manure than does the daily spreading of manure. This hypothesis was supported by the results of the model. The impact on farm income resulting from the White Clay Lake stabilization project was estimated by determining the difference between the status quo income associated with option A and the estimated income assuming option D was adopted. (These options are described in Table 8.1). Status quo income was estimated to be $76,632. As can be seen in Table 10.2, the farm simulation closely approximated the actual total acreages of cornland, oatland, and hayland as well as production of grain forages, and milk. With a 90 percent subsidy rate for the option D manure storage facility net pre-tax earnings were estimated to be $77,890 (See Table 10.3) providing an income increase of $1,258.

Table 10.1--Annual Recreation Benefits at White Clay Lake Based on 7,477 Visits

Year [a]	Change in Consumer Surplus	Discounted at 7-1/8 %	Discounted at 15 %
		---Dollars---	
1977	0	0	0
1978	0	0	0
1979	0	0	0
1980*	2,805	2,130	1,604
1981	2,805	1,988	1,395
1982	2,805	1,856	1,213
1983	2,805	3,077	1,870
1984*	4,973	2,867	1,626
1985	4,973	2,677	1,414
1986	4,973	2,499	1,229
1987	4,973	3,155	1,446
1988*	6,726	2,945	1,257
1989	6,726	2,749	1,093
1990	6,926	2,566	951
1991	6,726	2,918	1,007
1992*	8,194	2,724	876
1993	8,194	2,543	761
1994	8,194	2,314	662
1995	8,194	2,557	664
1996*	9,455	2,387	578
1997	9,455	2,228	502
1998	9,455	2,080	437
1999	9,455	2,168	424
2000*	10,559	2,024	369
2001	10,559	1,890	321
2002	10,559	1,764	279
2003	10,559	1,000	265
2004*	11,540	1,680	231
2005	11,540	1,568	200
2006	11,540	1,464	174
2007	11,540	1,471	163
2008*	12,424	1,373	147
2009	12,424	1,287	123
2010	12,424	1,197	107
2011	12,424	1,189	99
2012*	13,229	1,110	86
2013	13,229	1,036	75
2014	13,229	968	65
2015	13,229	953	60
2016	13,961	890	52
2017	13,961	831	45
2018	13,961	775	39
2019	13,961	759	36
2020*	14,633	710	34
2021	14,633	664	31
2022	14,663	620	28
2023	14,633	579	23
2024	14,633	540	21
2025	14,633	504	18
2026	14,633	470	16
Total discounted change in consumer surplus		$80,593	$24,091

[a] Years in which water quality changes occur are denoted by an asterisk.

Table 10.2--Comparison of Simulated Dairy Farm Operation with Representative Farm Operation, White Clay Region, Wisconsin, 1977

Item	Actual	Simulated
Pre-Tax Earnings	$73,943	$76,632
Milk Production		
Per Cow	140 CWT	140 CWT
Total Sales	$111,000	$108,354
Herd Size		
Dairy Cows	80	80
Replacement	90	90
Crop Average (Yield,Acre)		
Cornland	160 Acres	163 Acres
Grain	93 Acres (75 bushels)[a]	67 Acres (83 bushels)[a]
Silage	67 Acres (16 tons)	96 Acres (16 tons)
Oatland	35 Acres (60 bushels)	30 Acres (74 bushels)
Hayland	105 Acres (2.36 tons)	110 Acres (2.15 tons)
Purchases		
Fertilizer	$1,400	$3,173
Food Supplements	$2,000	$6,650

a/Figures in parentheses are per acre amounts.

Source: Information for the representative farm are from personal interviews.

Table 10.3--Technology Choice for Wisconsin Dairy Farm with Various Cost-Share Rates

Subsidy	Option Chosen	Net Pre-Tax Earnings	Total Subsidy	Fertilizer Expenditure
		Subsidy on Storage Capacity Only		
0	A	$76,632	0	$3,173
41	C	76,637	$6,903	592
50	D	76,859	8,744	590
90	D	77,890	15,739	590
		Subsidy on Storage Capacity and Equipment		
32	C	76,640	6,979	592
40	D	76,895	8,988	590
90	D	78,554	20,239	590

To determine the total farm impacts in the watershed it was necessary to extrapolate the results from the representative farm to the other farms participating in the project. It was assumed that these impacts would be proportionate to herd size. The estimates for the fourteen farms in the watershed are presented in Table 10.4. Since our benefit-cost computation requires total benefit value, the 10 percent farm cost-share that has been netted out by the LP model is added to the net pre-tax change in farm income. Total discounted farm impacts for these farms are $286,150 and $140,208 for the 7-1/8th and 15 percent discount rates, respectively.

Table 10.4--Project Benefits to Farmers in White Clay Lake Watershed

Farmers	Animal units a/	Estimated Annual Benefits
1	60	$ 975
2	60	975
3	50	613
4	145	2,357
5	55	894
6	50	813
7	100	1,625
8	40	650
9	65	1,057
10	120	1,950
11	60	975
12	185	3,007
13	115	1,869
14	190	3,088

a/Animal units are expressed in thousands of pounds, consequently, it may not necessarily coincide with actual number of livestock

Project Efficiency

As was the case in the Mirror and Shadow Lakes analyses project efficiency will be examined by comparing the present value of total discounted project benefits to discounted project costs. Benefits require the summing of the estimated recreational benefits and the farm benefits reflected by income changes. Total recreational benefits are $80,593 and $24,091 for 7-1/8 and 15 percent discount rates, respectively. The corresponding on-farm benefits are $286,150 and $140,209. Therefore, total project benefits are $366,743 and $164,350 when discounted at 7-1/8 and 15 percent, respectively. Total discounted project costs are $276,635 and $262,055 for the two discount rates and the relevant benefit-cost ratios are 1.33 and .63.

This apparent conflict in results does not lead to easy decisions regarding project justification. However, as is often the case an examination of the circumstances lends insights that can be helpful. In the case of White Clay Lake the magnitude of recreational benefits is not nearly so large as that at Mirror and Shadow Lakes. This is due to the small user population at this lake. This analysis did not consider a growth rate, but assumed a constant use pattern. This is perhaps not a realistic assumption, but it does avoid the problem of choosing a growth rate that is likely to draw possible criticism from project opponents who argue that benefits have been overestimated.

In addition to allowance being made for increases in the user population consideration should also be given to the value placed on existence and option values which were not estimated.

It does appear, however, that the magnitude of the values placed on these consideration would have to be quite large to justify the project when discounted at a 15 percent rate. Thus, it appears that the critical issue centers on the choice of the appropriate discount rate. Our analysis indicated that the project is justified at the 7-1/8 percent discount figure, and is not justified if evaluated at the 15 percent discount rate. A rate of approximately 10 percent will produce a benefit-cost ratio of one, without consideration given to growth rate, option or existence values.

Cost Sharing

Efforts to encourage voluntary participation in controlling nonpoint source pollution rely heavily on cost-sharing programs. From a policy standpoint the most interesting issue to examine was the determination of the break-even cost-share (subsidy) rates. The break-even subsidy rate can be identified as that rate which leaves the income of the farm unchanged after project adoption. At this rate, an income maximizing farmer is indifferent to the choices of implementing and not implementing the pollution reducing process.

As indicated above, there are two reasons this break-even subsidy rate is less than one-hundred percent of the cost of implementing less-polluting manure handling techniques, i.e., these techniques result in more nutrients being incorporated into the soil, thereby improving soil quality and decreasing purchases of commercial fertilizer, and these management systems require fewer labor and machinery hours to handle a given quantity of manure than do other systems such as daily surface spreading. Such benefits should help offset the capital costs incurred in adopting manure storage systems. [12/] The extent of these benefits was demonstrated in the preceding analysis on farm income.

To examine the cost-share issue we will consider two cost-sharing programs. The first program is similar to the one administered at the White Clay Lake. Funds can only be used to finance the construction of manure storage facilities; participants must finance the purchase of all manure collection and spreading equipment. Participants are required to choose between management options B, C, and D, (Table 8.1) and per-farm grants are limited to \$26,000. This figure equals the amount of funds received by some individuals under the White Clay Lake program. Each of the management options (B, C, or D) results in identical levels of nutrient runoff. Therefore, in terms of pollution, federal and state governments should be indifferent to an individual farmer's choice of these options.

The second program also allows a choice between B, C, and D. However, this program would allow subsidy funds to be applied to all categories of capital costs, including equipment, which are incurred in implementing one of the three options. The limit on per-farm payments under this program is also \$26,000.

Both programs directly affect farm operations and the level of net pre-tax income by changing the investment costs associated with options B, C, and D. Hereafter, the proportion of investment expenses absorbed by participants in the cost-sharing programs is referred to as the cost share.

The participant's cost-share rate for system i under program j, r_i^j (where i = B, C, D and j = 1,2), can be calculated for any given subsidy rate, s, and the set of rules governing the cost-sharing program. Let K_i represent the per-ton cost of capacity (including the cost of either a piston pump or a stacker) needed for option i, and let E_i be the per-ton cost of other equipment (in the case of the three options, a spreader) needed to implement that option.

In the first subsidy program,

$$r_i^1 = \frac{(1-s)K_i + E_i}{K_i + E_i} > 1-s, \ (i=B,C,D) \qquad (10.1)$$

and in the second program

$$r_i^2 = \frac{(1-s)\ K_i + E_i)}{K_i + E_i} > 1-s \qquad (10.2)$$

Clearly, for any positive value of s, r_i^1 exceeds r_i^2 for all i.

Under each program, there is a maximum percentage of the total investment costs for an option which a revenue maximizing farmer will be willing to absorb and still use that option. Corresponding to this maximum percentage, which is referred to as the "break-even cost share" ($\hat{r}_i^j$), is the minimum, or break-even subsidy rate" ($\hat{s}_i^j$), i.e.:

$$\hat{r}_i^j = 1 - \hat{s}_i^j \qquad (10.3)$$

Because the government will only help pay for storage capacity costs, (K_i) in the first program, but will help pay for all capital costs (K_i+E_i) in the second program, the break-even cost-share rate for option i is less in program 2 than it is in program 1, i.e., $\hat{r}_i^1 > \hat{r}_i^2$.

The government's proportion of cost, s, was varied under each program, and the level of farm income and choice of manure handling system was observed. The results of these simulations are reported in Table 10.3.

Under rules of the first cost-sharing program, where only the storage facility is subsidized, the break-even subsidy rate is approximately forty-one percent. Since storage facility costs are a higher proportion of total investment costs for option C than for the other options, r_C exceeds both r_B and r_D. Therefore, the higher rate of government subsidization of the former option's capital costs make it a relatively attractive investment option. Option C is the only handling process used in the model when the break-even rate is offered, and total subsidy payments are approximately $6,900, well below the per-farm grant limit. As subsidy rates increase, the differences between the options' capital costs decrease. For rates of fifty percent and above, the lower labor requirements of option D make it more attractive than option C from the vantage point of the representative farm.

In the second program, where all equipment can be subsidized, the break-even subsidy rate is thirty-two percent. Again, system C is choosen by the model at the minimum subsidy level, and total payments to the farm are a little less than $7,000. As the subsidy rate increases above forty percent, it is profitable to switch to option D.

There is no combination of cost shares and program rules for which option B is used in the model. Its comparatively high capital cost outweighs benefits the farm would gain from the slightly higher delivery of nitrogen from a ton of manure. This benefit is small because the farm is barely able to use all the nitrogen delivered by options C or D. The shadow price of a pound of nitrogen in the break-even runs is five cents. Shadow prices for phosphorus and potassium are higher, indicating that amounts of these fertilizer elements available are fully utilized on the farm. However, a switch to option B would not increase the production of phosphorus and potassium.

Finally, when a subsidy rate in the range of thirty-two to fifty percent is offered to cost-sharing program participants, rules of the program affect the choice between manure handling systems. Under the institutional structure of the present program, option A is chosen if a subsidy rate between thirty-two and forty percent is offered. System C is used if an identical rate is offered under the second set of rules. Similarly, if a subsidy rate of forty to fifty percent is offered under the first rule set, option C is selected; but in the same range of subsidy rates for the second institutional structure, handling method D is the most profitable choice. These results indicate that farmers would be able to pay a rate significantly higher than the cost-share arrangements used at White Clay Lake.

These results have significant policy implications. In the case of manure storage facilities, it appears that the farmer may actually be benefiting from the employment of cost-shared nonpoint source pollution control measures. If so, re-evaluation of the existing cost-share structure is in order. We are not claiming that our findings should be adopted as they stand. However, the direction of our findings does have the support of other research efforts, and with the potential benefits as great as they appear to be, the issue should justify further investigation, particularly with public funds as scarce as they are.

Change is difficult to obtain, particularly when it requires higher cost shares from the participator. To ease acceptance of this change an educational program should capitalize on the farmers sensitivity to the probability of private gain from certain cost-sharing programs. Consequently, the educational program must inform farmers of the possible gains from adopting anti-pollution technology - not only the direct gains, such as nutrient retention associated with manure storage facilities, but also the indirect ones, such as more free time, healthier cows and a means to delay manure spreading during inclement weather. In addition, a comprehensive educational program must point out the other financial incentives available, such as tax deductions and low-interest loans. Perhaps a combination of incentives might be appropriate. The various incentives are not mutually exclusive; thus, a combination of them might form an attractive package. For example, a low-interest loan might be used to supply the capital for the farmer's cost share.

This discussion has dealt only with cost sharing and manure storage facilities. However, nonpoint source pollution control measures include many other structural and non-structural approaches, and all are cost shared. To provide an efficient cost-share program, it will be necessary to conduct similar research efforts for each of these.

CHAPTER 11

LAKE MANAGEMENT ORGANIZATIONAL STRUCTURE

The Local Level

The discussion and evaluations provided in the final chapter draws not only on two case studies at Waupaca and White Clay Lake, but also draws heavily on the authors' participant observation in working with hundreds of voluntary lake associations and over 100 formal lake districts. This chapter is thus based substantially on ethnographic sources.

The presentation on local organizational structure and the state/federal role in lake management is based on the following assumptions:

1. The lakes are relatively small (<10,000 acres).
2. The shorelands have been developed for residential purposes.

If the lake is large or the shoreland has not been developed, e.g., public lands, the model presented below is not applicable. In those cases, a more direct involvement by state or federal agencies is necessary.

Enabling Authority/Responsibility

States are the sovereign authority. The federal government has those powers given to it by the U.S. Constitution. Local units of government have those powers given to it by the State Constitution or by act of the state legislature.

Water quality management is no exception. Certain regulatory functions have been given to the U.S. Army Corps of Engineers and EPA, but the core of the police power regulating public water resides with the states. Some states have delegated certain powers, such as shoreland and floodplain zoning, to local units of government.

In Wisconsin in 1974, the state legislature passed legislation which allowed a local community to accept responsibility for their lake and provided them with authority to engage in a variety of lake management activities.

The purpose of the law (Chapter 33, Wisconsin Statutes) is "to embark upon a program of lake protection and rehabilitation to fulfill the state and local program of lake protection and rehabilitation, to authorize a conjunctive state and local program of lake protection and rehabilitation to fulfill the positive duty of the state as trustee of navigable waters and protect environmental values.

In passing Chapter 33, the legislature went on to say "that local districts should be formed by persons directly affected by the deteriorated condition of inland waters and willing to assist financially, or through other means, in remedying lake problems." Thus the legislature tried to match willingness to accept responsibility with the authority to carry it out. The following activities were specifically enumerated, but not limited by enumeration:

- aeration
- nutrient diversion
- nutrient removal or inactivation
- erosion control
- sediment manipulation
- bottom treatment

Police powers to regulate land use in the watershed or to regulate surface water use were not granted. These powers had previously been granted to general purpose units of local government (cities, counties, villages and towns). Subsequent amendments provided that lake districts could provide sanitary services with the permission of the town board. Inspection of septic systems is the one regulatory power possessed by lake districts who have received sanitary powers.

Enabling legislation for a special purpose unit of government was necessary because general purpose units, such as the county and town, had not responded to the need to manage lakes. Even though they are local officials, most of the county or town board members do not live by a given lake. Other matters (roads, social services) are more important. On the other hand, special purpose units proliferate government, diffuse authority, and confuse citizens. Nevertheless, they may be the only practical alternative in certain situations. Lake management in Wisconsin appeared to be such a circumstance.

Boundaries/Creation

The legislature felt that local people around lakes should form the district. It provided a mechanism for a majority of landowners to petition the town board or county board. (Districts totally within cities or villages can be formed directly by the city council or village board.) Due process was ensured through notice and hearing requirements, decision criteria, and appeal procedures.

The law, however, left the question of boundaries entirely in the hands of the petitioners and the board receiving the petition.

In some communities, the boundaries are obvious. For instance, Mirror Lake and Shadow Lake in the city of Waupaca. Shadow Lake shoreland is publicly owned and heavily used by the entire city. Mirror Lake receives less public use, but more riparian use.

The political limits of the city of Waupaca provided the practical definition of community. The lake district was created by city council action to include the entire city. This decision minimized the chance of controversies. If artificial lines had been drawn through the city, people on the lake district side would have complained about property owners on the other side of the street who did not have to pay. The community-of-interest for these two water bodies was clearly the entire city. If only riparians had been included, they would have been unable to raise the 20 percent local share. They would have been bitter about other people in the city who used the lake without paying. They would also have resented a board of commissioners, consisting of city council members who represent the entire city and most of whom would not have been lake district residents.

In other cases, the boundary decision is difficult. The basic considerations are related to sources of the problem distribution of benefits and political relationships.

Contribution to Problem. From the viewpoint of physical management, the best boundary is the entire watershed. The lake is a product of the watershed. Unplanned development, certain farming or logging practices, and disposal of waste in the watershed can threaten the lake.

Lake property owners are likely to point fingers at upstream neighbors and demand that they be forced to "clean up their act" and help pay restoration costs.

Protection activities are most feasible in the watershed when pollutants can be prevented from entering the water, rather than recovering or extracting them from the lake water.

In some cases, due to the proximity to the lake, education, or strong community spirit, landowners in the entire watershed will support forming a lake district. White Clay Lake District was formed in this manner. The watershed is small and it was possible to reach a consensus. In a small watershed, the people also are likely to benefit from the solution. They are close enough to see and use the lake, and benefit from enhanced property values.

Distribution of Benefits. In some cases the source of the problem is far upstream with landowners, industries or municipalities which have no interest in the lake. The property owners will still comment about the culprits upstream, but it may be futile to attempt to include them in the boundaries. The culprits fit into the physical management picture, but they are not part of the community-of-interest. They do not identify with the lake, the lake people, or the lake district.

In many cases, the upstream landowners are farmers with strong ties to the county board and town board. The lake people, especially the seasonal residents, often are not as involved in local politics and usually do not have as much influence. If a proposed district boundary is drawn far into the watershed, it may not be possible to get a majority of landowners to sign the petition to create a lake district. Even if large landowners in the watershed are outnumbered by numerous lake lot owners and the petition obtains enough signatures, the procedure could hit a snag at the county board or town board. These boards are usually sympathetic to landowners who complain that (1) they are too far from the lake to benefit, and (2) they would pay a heavy tax because of large property holdings. The town or county board can trim the size of the lake district and has often clipped pieces of farmland off the edges of the proposed district. In a few instances, the opposition has become so vocal that the entire petition was denied.

Political Judgment. To clear boundary hurdles, the following guidelines have been developed for the local leaders:

1. Include all riparian land;
2. Include non-riparian land that is used the way it is because it is close to the lake (bait shop, dinner club, campground, subdivision, etc.); and
3. Include as much of the watershed as it is politically and logistically possible (22).

Above all, local people must define the boundary of who cares and why. The procedure is set by law; the local county or town government makes the final decision on how far out from the lake the lake district will go. It is a clear political choice. As the lake district expands, it takes in more people. With more people in the district, it may be more difficult to approve projects at the annual meeting. People further from the lake are less likely to tax themselves for lake projects. If the lake district consists of a narrow band of shoreland around the lake, projects may be easily approved, but the district would have limited financial ability because of the smaller tax base.

The enabling statute sets no restrictions on the boundaries. The decision on boundaries is made by local people who understand the management implications, the tax base implications, and the local political realities of their decision. The local community must grapple with the issue and decide who is part of that community-of-interest.

The community-of-interest premise replaces old political boundaries. This "eco-system" approach includes all land whose present or future development is oriented to the lake or whose use has a direct effect on the quality of the lake environment. An offshore subdivision, highly erodable farmland in the watershed, lake-associated wetlands should all be part of the lake management district. To include critical areas, the district must be able to cut across traditional political lines such as townships.

Although lake district boundaries can cut across municipal lines, they do not necessarily include entire watersheds--which would be the ideal management situation. In some cases, as indicated earlier, upstream farmers feel no community-of-interest with the lake people, and any effort to force them into a lake district would spell political and organizational disaster. In other cases, such as the Upper Willow Flowage in northwestern Wisconsin, it has been possible to mobilize housewives and the local high school Future Farmers of America Club in a petition drive that collected signatures from thousands of landowners and resulted in a St. Croix County Board resolution creating a district encompassing the entire watershed of 112,000 acres.

Governance/Decision-making

Voting. Lake districts are unique in terms of voting rights. As a unit of government, all adult residents of the district can vote. But, in addition, property owners who reside outside the district are also enfranchised. This right of non-residents was granted with the original statute. However, a court challenge resulted in an Attorney General's opinion that a statewide referendum was required before the right to vote was enlarged in any way. That referendum was held in November, 1980 and passed by nearly a 4:1 margin.

Most voting takes place at the lake district's annual meeting which by statute must be held in summer so that cottage owners can more easily attend. Written, as well as published notice must be provided--again to help ensure the involvement of seasonal residents.

The statute requires that all projects costing the district over $5,000 must be individually voted on at the annual meeting. The overall budget and tax must also be approved. Typically, one commissioner is elected each year. Eligibility for voting, when there are multiple non-resident owners, and other operating procedures are contained in the district's by-laws.

Commissioners. In districts created by city councils, such as Waupaca, or village boards, the governing body also acts as the lake district commission. The standard form of governance in other districts including White Clay Lake is five commissioners who carry out the wishes of the annual meeting. They have limited discretion beyond the authority spelled out in the by-laws or provided by specific authorization of the annual meeting.

The commission consists of:

1. Three members of the district, elected for three year terms on a staggered basis. (Two may be non-resident property owners.)
2. One representative of the county board from the Soil and Water Conservation Committee or nominated by the Committee.
3. One member of the governing body of the municipality (town, village or city) with the largest equalized valuation within the district.

Perception of Benefits and Costs. University researchers and agency bureaucrats can calculate the benefits and costs of a project if they can agree on a set of impacts to measure, a set of assumptions about those impacts, and the appropriate discount rate (interest rate to determine the present value of future benefits and costs).

Local citizens and local government leaders may perceive different impacts, are not likely to specify their assumptions or accept someone else's, and may have a difficult time conceiving of discounted values beyond the next term of political office. In short, the benefit-cost ratios calculated by outsiders may not be very meaningful to the local lake district commission or village board. Indeed it may be difficult to get enough time on the agenda to explain discount rates and benefit-cost ratios.

The most powerful stimulus for an elected official is the desire of his/her constituents. If most property owners in the lake district want the lake dredged, the leaders will typically work toward that goal without formal analysis. They will know the local cost in tax dollars. They will have subjective feelings of expected benefits. They are not likely to seek more sophisticated analysis, especially if the property owners are willing to pay the price.

It is important to provide community leaders with information about the potential impacts of the project. It is naive to attempt to impose a sophistication that is out of character with local control and town-hall democracy.

In a general way, the community realizes that approving a lake project means some other project will have to be put off. Sometimes community leaders will force citizens to specifically recognize the opportunity costs of their decision.

Even if the costs are focused, the perceived benefits are not. "Better fishing," and "improved view," and "a lake the grandchildren can swim in," are benefits with differential utility to individual property owners.

In the discussions at the annual meeting, goals and expected outcomes of the project may be clarified. But in the end, each property owner will cast his/her vote based on idiosyncratic values; the determining factor may well be whether the individual has grandchildren, or whether their view will be improved.

Local Finances/Internal Equity

The financial capability and willingness of a community varies. In every community there are many issues--a recession, a school bond issue--that all interact and have an impact on the community psychology. These factors determine what people are willing to vote for in taxing themselves. This is the financial reality of lake protection and rehabilitation.

The sources of local finances of a lake district can be divided into the following four areas: general property tax, user charges, special assessments, and local enterprise.

General Property Tax. At the lake district annual meeting, a budget and a tax are adopted. The tax, which is used to cover general operating costs of the district, may not exceed the rate of 2.5 mils of equalized valuation, and must be evenly applied on all taxable property in the entire district. It is used for activities that do not have differential impact on individual properties. Public property is not subject to property tax. The tax is included with the general property tax bill an collected by the local general purpose unit (town, village, city). Unpaid taxes become a tax lien on the property.

The city of Waupaca collected 0.9 mil per year for two years to pay for the Mirror and Shadow Lakes project.

User (Special) Charges. Some activities provide special and temporary benefit to individual properties. Examples include weed harvesting, swimmers itch and algae control, and garbage pick-up.

The special charge is also used in communities with heterogeneous property. For instance, a lake district might contain 50 cottages averaging $20,000 each and five farms averaging $400,000 each. A one mil levy would cost the cottage owners $20 each and the farmers $400 each. To avoid that injustice, such communities often use a special charge with a standard fee based on a formula, e.g., lake lots $50, and backlots $25.

Under Wisconsin law, special charges must be collected directly by the lake district. If an owner refuses to pay, the charges can be put on the tax roll.

A user charge can also be applied to users of the lake. The charge must be based on use of facilities such as boat ramps since free use of the water is a constitutional right. The fee is assessed by whoever owns and operates the facility. Fee maximums are controlled by the DNR. Lake districts have not been using this mechanism because they usually don't own public access facilities and collection of fees is not economically efficient.

Special Assessment. Financing major lake district projects often requires a special assessment. Waupaca was able to avoid a special assessment because of the large tax base of the entire city. However, as the property value impact analysis above indicated, the unequal distribution of benefits could have justified such an assessment in this instance. If districts need more than 2.5 mils annually to pay for a big project, they are required to go through a complicated procedure as follows:

1. After a project is approved at the annual meeting and by DNR, and after receipt of state and federal grants, the lake district commissioners know the local cost share for the project. Commissioners determine the

benefits to accrue to each parcel of land. Size, proximity to the lake, present and potential land use, and other factors are considered in making fair assessments. The special assessment often varies from waterfront properties to outlying areas.

2. Notice of the special assessment must be given to each person having an interest in affected land. The notice must indicate where assessments may be reviewed. In addition, the notice sets a day--within three days after the expiration of the 30-day review period--on which the commissioners will hear objections to the assessments. If the assessment is increased, a new hearing with notice must be provided. After this hearing, the commissioners will publish a final determination of assessments once in the local newspaper and send a notice to each person having an interest in affected land. If there are objections, people have 40 days to appeal to the circuit court.

3. The assessments can be paid in lump sum or they can be paid in installments on principal plus interest. If property owners choose to pay in installments, the lake district will borrow money based on the collateral of the special assessment payments still due.

Local Enterprise. Local efforts to raise dollars are limited only by local imagination. Successful fund raising efforts have included fishing contests, carnivals, street dances, winter festivals, picnics, and one district (little Muskego Lake) marketed beer bearing the district name.

Some communities make an in-kind contribution. For instance, the district supplies labor as an in-kind contribution instead of cash, and a value is credited for that labor (the value the contractor would have charged). The White Clay Lake District avoided any tax with such in-kind service.

Leadership/Motivation

Types of Leadership. Almost every project has a ramrod, someone who never gives up on the project. That person has to deal with professionals on the basis of mutual respect. He or she must understand the principles of lake management, the basics of the management options under consideration, and the role of the various agencies. More than any other quality, the individual must cope with frustration and persist. The Waupaca project went smoothly and fast. The White Clay Lake project took a little longer as cautious farmers waited to see how their neighbors' operations had been affected by the project. But it went smoothly with few exceptions. Some other lake district projects, especially some dredging operations, have taken years to obtain permits and years to complete. Through all the project years, volunteer (unpaid) leaders must maintain momentum. Leaders of lake districts, or any organization for that matter, have two basic functions to perform; productivity and maintenance. Certain leaders are task-oriented. These zealots know the goal and the steps required to get there. They are usually impatient with anyone who has less faith, confidence, and energy than they have.

In organizations like lake associations and lake districts, zealots may get the organization started and may even get a major project finished. However, eventually the zeal becomes too "heavy" for the other members. At that point, the other members abandon the organization or throw the zealot out of office at the next election.

The other function of leadership is maintenance of the organization as a viable entity. Zealots usually fail to maintain *esprit de corps*. They ignore the human needs of their members to have fun, to be appreciated, and to occasionally share some of the limelight. In short, zealots often fail to provide exclusive benefits to the hard-working members.

As an organization matures, its leadership often shifts from a zealot to a manager/diplomat for leadership. Sometimes the same individual evolves with the organization. In most cases, a new leader emerges with a temperament suited to the changed role. This leader is likely to seek compromise rather than confrontation.

In lake organizations, the manager/diplomat makes sure that everyone receives meeting notices, invites DNR to the meetings, plans an annual picnic, as well as being responsible for keeping the aerator working and supervising the weed harvesting.

In extreme cases, all substantial efforts fade as the manager/diplomat is so concerned about upsetting someone that he or she cannot make any decisions. After the organization proceeds under such mellow leadership for a number of years, it is ripe for a new zealot to take charge or for a zealot with a new organization to replace it.

A few people can simultaneously be a charismatic zealot charging toward a goal and a people-manager keeping the troops happy. More often, leaders for an organization are chosen to complement each other. The lake district chairman may aggressively move the organization toward its goal by securing money, equipment and land. The secretary, on the other hand, may focus internally on maintaining rapport with the members, personally greeting them at meetings and making them feel they have a personal friend among the officers.

In other cases, the district chairman may enjoy a ceremonial role while the dredging committee chairman pushes the project to completion.

Few organizations consciously choose leaders to provide the right balance for their stage of organizational evolution. Some end up with all zealots ("all chiefs") and lose their members ("no Indians"). Others pick all diplomats who forget why the organization was formed.

Lake organizations should consciously choose balanced leadership.

Incentives for Leadership. Inertia tends to maintain the status quo. In the case of lakes, this means continuing without any management plan or effort. Overcoming inertia requires special involvement. There are costs to involvement, especially for leaders.

Involvement means exposure to uncomfortable ideas, exposure to controversy, exposure to hostility, and exposure to suit. It also means out-of-pocket expenses for travel to meetings, telephone calls, etc. The biggest cost is time; an opportunity cost of other activities that must be delayed because of commitment to the lake project. Family may be neglected, economic opportunities for side-incomes lost, hobbies sacrificed, and health threatened.

Olson concludes that because of these costs, apathy is rational under two conditions:

1. The group is large enough that the individual cannot clearly see his/her involvement making a difference in the outcome; and
2. The benefits of success are not exclusively awarded to the participants (37).

Thus, in a large lake community, it is easy for everyone to assume the rational attitude "George" will do it. It is not clear that an individual's involvement will change the lake, and if the lake is cleaned up, the lazy freeloaders will benefit as much as those who sacrificed to get the job done. The typical result: nothing happens.

To overcome apathy, it is necessary to change the two conditions. Functional group size can be kept small (5-15) by wise use of committees.

Committees need a clear charge, a time frame, and strong leadership. Agendas, minutes, social time, and other techniques can be used to improve the effectiveness of committees--primary of which is keeping the committee members interested.

The second condition cannot be directly changed when a common good is involved. Lakes, like the village square, suffer from the tragedy of the commons (17). Everybody owns the lake; everyone attempts to maximize their use of the free public good; and no one manages the resource because the benefits of investment will have to be shared.

However, it is possible to provide side benefits which are exclusive to the people who are involved, especially the leaders. Social approval is the most general benefit which makes a person proud to accept civic responsibility. Newspaper stories, recognition at public events, and awards can highlight the approval and provide additional esteem and prestige. Such efforts may seem trivial, but if a group cannot offer cash to its leaders and workers, it must provide some other selective incentive.

There may be other incentives in specific cases. Public officials may be attracted to the project because of the prospect for outside grants. If they can take credit for obtaining these funds, local citizens may reward them with votes at election time. This assumes that citizens view the project and the entry of outside dollars as positive.

In addition, local leaders sometimes gain a disproportionate share of lake protection/restoration project beneifts. In Waupaca, a local leader was also a riparian property owner on one of the lakes to be managed. This leader obviously had a greater-than-average stake in maintenance and management of the lake. Other leaders indicated that for them the opportunity to meet and exchange ideas with a variety of professional people from the university and state and federal governments was an incentive.

Whatever the potential incentives, they must be recognized and used. Self-interest and parochialism are not necessarily bad. Sufficient degrees of parochialism are essential to even begin to undertake lake management.

State and Federal Roles

One approach to lake management is direct management by a state or federal agency. This approach is most common on public lands. The U.S. Army Corps of Engineers and the Bureau of Land Management provide direct management of large reservoirs. State natural resource agencies typically have authority to provide direct management services and sometimes do.

In geographic areas with a few large lakes, direct management may be necessary. There may not be a local community-of-interest around a large lake to take on management responsibility. Consequently, the community-of-interest may be so broad that only a state or federal agency can properly represent it.

The discussion in this section is not oriented to such situations. The decision-making process is entirely different. In those situations, the agency has strong prerogatives and may exercise them, often with little regard for local property owners. There may be no local property owners if the lake is surrounded by public lands.

This discussion is oriented to geographic regions with small, numerous lakes. In such situations, state and federal agencies are assumed to provide enforcement of fish, game, and water quality regulations, but do not have sufficient personnel to provide direct management (day-to-day personalized care and concern). A local community-of-interest is more likely to exist or be developed around small lakes. The role of the state and federal agency is supportive rather than directive.

A summary of the relationship between the state and local lake districts in Wisconsin is shown in Figure 11.1.

Educational Assistance

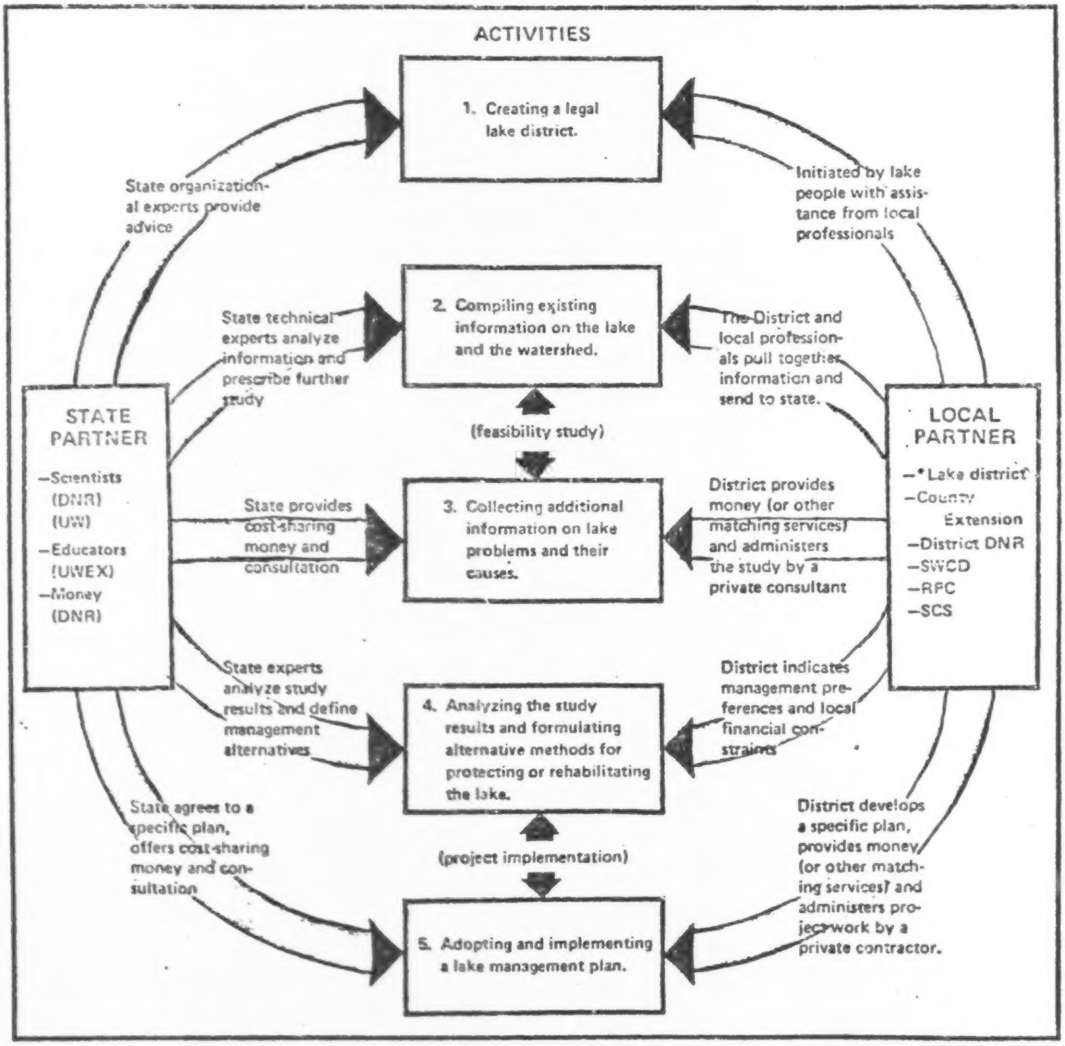
All democratic processes require citizen education whether the citizen will use that information in direct participation at annual meetings, election of representatives, or public participation at hearings. Citizens should understand the basic principles of resource use and conservation and the process by which management decisions are made.

Education is especially important in the lake district scheme in Wisconsin. Chapter 33 requires direct decision-making by citizens at the annual meeting. The spark to create the lake district must be ignited by property owners who understand their lake and are aware of its management potential through Chapter 33.

Lake property owners must understand the basic physical and chemical features of the lake ecosystem and its relationship to the watershed. They need to know the technical options available to deal with the problem or avoid the problem. Equally important to knowing "what" can be done, is knowing "who" can do it. The institutional framework must be understood before it can be used. Enabling authority, required permits, and sources of financial assistance are just as much a part of lake management as BOD (biochemical oxygen demand), sedimentation rates, and Secchi disc (device used to measure water clarity) readings.

The Wisconsin lake management program includes statutory recognition of the educational role. The University of Wisconsin Extension (UWEX) has responsibility to provide a systematic flow of information to lake

Figure 11.1--Provisions of State Assistance to Local Lake Districts


ACTIVITIES
1. Creating a legal lake district.
State organizational experts provide advice
Initiated by lake people with assistance from local professionals
2. Compiling existing information on the lake and the watershed.
State technical experts analyze information and prescribe further study
The District and local professionals pull together information and send to state.
(feasibility study)
STATE PARTNER
–Scientists (DNR) (UW)
–Educators (UWEX)
–Money (DNR)
LOCAL PARTNER
–*Lake district
–County Extension
–District DNR
–SWCD
–RPC
–SCS
3. Collecting additional information on lake problems and their causes.
State provides cost-sharing money and consultation
District provides money (or other matching services) and administers the study by a private consultant
State experts analyze study results and define management alternatives
4. Analyzing the study results and formulating alternative methods for protecting or rehabilitating the lake.
District indicates management preferences and local financial constraints
(project implementation)
State agrees to a specific plan, offers cost-sharing money and consultation
District develops a specific plan, provides money (or other matching services) and administers project work by a private contractor.
5. Adopting and implementing a lake management plan.

communities. That flow begins when local citizens contact County Extension agents regarding creation of a lake district. The educational service continues as the district matures. To serve a broad range of education needs, the two state specialists employed by the UWEX have complementary expertise in the natural sciences and social sciences.

The sequence of educational efforts varies from community to community. As noted earlier, rural communities such as White Clay Lake typically are involved in intensive education efforts as they build a new governmental structure--the lake district. Urban communities such as Waupaca rely on their existing municipal government. Education tends to be limited to the city council, city employees, and a small percentage of property owners.

Table 11.1 outlines the typical sequence of education activity in a community. In addition to the major events, a continual flow of information is maintained through daily letters and telephone calls handled by UWEX and DNR personnel. These professionals also attend numerous lake district meetings on an invitation basis. To assist in this effort, numerous educational materials such as following, have been developed:

Bulletins

- "Role of Lake Property Owners and Their Organizations in Lake Management" 2nd Ed.
- "Wisconsin Wetlands"
- "A Guide to Protecting Wisconsin Wetlands"
- "Lake Levels"
- "Guide to Wisconsin's Lake Management Law" 4th Ed.

Slide/Tape Sets

- Understanding Lakes and Lake Problems

TABLE 11.1--OUTLINE OF EDUCATIONAL EVENTS

1. The County Extension agent and lakeshore community leaders attend a regional conference organized by a University Extension specialist.

2. Lakeshore community leaders meet with their voluntary lake association and a committee is appointed to explore lake district formation.

3. At the request of the organizing committee, the County Extension agent arranges a planning meeting with an Extension specialist. The specialist provides sample petitions and booklets. The committee defines the boundary of a proposed lake district and sets a date for a public educational meeting.

4. At the community meeting, the specialist discusses lake district formation and answers questions. The organizing committee discusses the proposed boundaries and the petition drive.

5. After the committee has collected signatures from a majority of landowners, the petitions are submitted to the town or county board. The County Agriculture and Extension Committee (or town board) is given responsibility to send notices to all property owners and hold a hearing. The County Extension agent arranges for a specialist to discuss the law with the county (town) board members holding the hearing. A formal public hearing is held with the county agent (town clerk) acting as secretary and a specialist in attendance to answer questions.

6. After formation, Extension and other local agencies assist the district in applying for state aid to conduct a feasibility study. Data is gathered under contract with a private firm.

7. At the completion of the study, the Department of Natural Resources provides the community with management alternatives. The lake district decides which, if any, alternatives they want to implement and applies for cost-sharing.

8. Throughout the process, Extension specialists provide educational materials and hold workshops on liability insurance, by-laws, wetland preservation, controlling waterweeds, taxation, and an assortment of other pertinent topics.

- Controlling Waterweeds
- Wisconsin Wetlands

Films:

- Lake Renewal Techniques
- Non-Point '83
- Runoff: Land Use and Water Quality
- Marion Millpond Story

Flyers:

- "Controlling Waterweeds"
- "Understanding Septic Systems"
- "Lake District--A New Alternative"

References:

- "Local Sources of Assistance"
- "Handbook for Lake District Commissioners"
- "Directory of Lake Protection and Rehabilitation Districts"

Technical Assistance

Local communities can obtain assistance from private consultants and from regional, state, and federal government agencies. Few communities have local expertise on a topic as complicated as lake management. In many states, these communities retain a consulting firm to assist them in conducting studies, applying for grants and permits, and managing the project.

Wisconsin communities obtain technical assistance from the state as well as private firms. The Office of Inland Lake Renewal was organized in DNR specifically to assist lake districts. By concentrating resources, it was possible for DNR to assemble an interdisciplinary team. The team has expertise in limnology, aquatic biology, engineering, hydrogeology, and soils.

Because of the likelihood of negative reactions by local people to outside intervention, the program only responds to requests for help. Local people, in essence, must ask for help. Much of the stigma normally attached to a regulatory agency is dissolved when (1) the early educational efforts are carried out by UWEX, and (2) DNR technical experts arrive in the community based on an invitation to assist. Additionally, the work is carried out through a local professional (DNR fish manager, County Extension agent, soil conservationist), who is an intermediary between the technical experts from the outside and the community.

After the Office of Inland Lake Renewal accepts a request for technical assistance from a lake district, the first response is typically a design for a feasibility study. While each study is comprehensive, it is designed with the particular feature of the lake in mind. For instance, groundwater would not make much difference to a lake with a large river flowing through it. No groundwater component would be included for such a lake study. Similarly, a lake with a large sewage treatment plant upstream probably does not need to worry about septic systems. However, if tertiary treatment or diversion are real possibilities, then a sanitary survey of private septic systems is in order. Similarly, a macrophyte study would be useless on a large windswept lake with algae problems.

In general, the following components are included in the study unless there is good reason to exclude them:

1. In-lake chemistry analysis.
2. Preparation of an isopleth map showing the bottom contours of the lake and the depth to hard sediment (thickness of the muck).

3. Nutrient budget for phosphorus entering and leaving the lake.
4. Water budget considering rainfall, evaporation, groundwater, direct surface runoff, and streams.
5. Groundwater study to determine water chemistry, slope of the water table, and rate of movement.
6. Surface water exchange (flow rate, phosphorus, sediment).
7. Sedimentation rate.

The lake district contracts the study to private consultants. However, staff members from the Office of Inland Lake Renewal monitor the quality of work through split samples, on-site inspections, training, and review of quarterly reports.

The results of the study are returned to the team that designed the study. Technical assistance continues with the drafting of management alternatives based on the study results. Typically, one of the team members will review the alternatives with the lake district commission and with the lake district members at the next annual meeting.

If a district decides to implement one of the alternatives and develops a management plan, additional technical assistance is provided in grant application preparation, developing bid specification and some monitoring of work. The project itself is usually contracted to a private firm.

Throughout the process, one of the DNR team members provides continuous liaison with the lake district. A local DNR employee from the regional office (inland lake coordinator) is also involved in all of the above steps. In certain situations, the local County Extension agent, DNR conservation warden, or county soil conservationist provide additional technical assistance as well as a local contact.

Technical assistance provided in this context has been welcomed by the lake districts. The districts and the government experts perceive the role to be one of advice. The experts are on tap, not on top.

Financial Assistance

The corollary to technical feasibility is financial feasibility. Since the federal and state clean lakes programs have no regulatory authority, financial feasibility of a project is determined by availability of agency grants and by the willingness of the local community to come up with their cost share.

Local willingness to pay is based on three subjective judgments: (1) can they afford the local share; (2) are the benefits they receive greater than their local costs; and (3) will the people who use the public access pay their fair share.

Opportunity Costs. The concept of opportunity costs is familiar to budget analysts and decision-makers at the state and federal levels. A decision by Congress to fund the Federal Clean Lakes Program means that some other public program cannot be funded. A decision by EPA to ask for Clean Lakes Program appropriations may reduce their chance of funding some other environmental program. A decision by the Wisconsin legislature to spend $1,150,000 on the Wisconsin lake management program means there is $1,150,000 less general purpose revenue for other purposes. A decision by DNR to request such funding may diminish the chance of getting approval for another program.

However, even at the state and federal levels, political judgment rather than economic efficiency is usually dominant. The alternative program that could be funded with "clean lakes money" is seldom clear.

Decision-makers are seldom presented with a choice of program A or program B. Their choices are made in the context of hundreds of hearings on various programs, numerous amendments to authorization and appropriation bills and party caucuses to hammer out a compromise that can command a majority of affirmative votes. Opportunity costs may take the form of legislators using their "chips" for clean lakes or for some other program. Opportunity costs are not likely to be analyzed by the whole legislative body. At that point, the process is dictated by political expediency and it may have to be. In a democracy, there are too many decisions and too many decision-makers for full deliberation by all decision-makers on each decision.

In other cases, there may in fact be no opportunity cost to the agency. Spending the funds on a certain program may increase the probability of other programs being funded. For instance, the Clean Lakes Program may generate good will for EPA and DNR. The resulting community support may be translated into political support for other programs.

Who Pays? Respondents in our study were asked who they felt should pay the most. Table 11.2 shows that polluters are the favorite target of every respondent group. Beyond the "bad guy" category, some differences emerge. White Clay Lake residents who received 90 percent (50-EPA; 40-DNR) cost sharing, and knew the cost-share ratios, give the federal government a close second. The implication of that rating is discussed in Chapter 6 under "Ascription of Responsibility."

It is interesting to note that lake property owners and recreationists are rated low by all respondents. It could be expected that lake residents would give themselves a low rating for selfish reasons. Similarly, recreationists might have rated themselves low because they were

Table 11.2-- Desired Distribution of Lake Project Costs

Group Who Should Bear Greatest Cost	Statewide	Waupaca Residents	White Clay Lake Residents	Mirror/Shadow Recreationists	White Clay Lake Recreationists
Lake Property Owners	5%	5%	3%	5%	5%
Visitors/ Recreationists	6	9	9	12	3
Polluters	59	63	40	50	58
Local Government	7	2	6	17	12
State Government	12	16	10	7	19
Federal Government	11	5	32	9	3
TOTAL	100%	100%	100%	100%	100%
(N)	(1341)	(131)	(32)	(56)	(61)

worried that fishing licenses would become more expensive if they rated recreationists high. But the statewide sample also rated lake property owners and recreationists low. It is true that most state residents use water for recreation and were rating themselves. However, only five percent of the statewide sample own lake property. Even average citizens who do not own lake property do not feel the property owners should pay the most.

The same trend is evident in Tables 11.3 and 11.4 showing mean and median ranking. Lake property owners, visitors/recreationists, and the federal government were all rated low in regard to responsibility to pay for water quality management. Except among White Clay Lake residents, polluters, state government and local government take top honors.

Recreationists, who are dependent on public access, rate the state somewhat higher than other groups in terms of responsibility to pay for water quality management.

The most dramatic insight from the tables is the low rating given water users--the lake property owners and recreationists. Water is apparently perceived as a public resource with public responsibility. There is little support for charging fees for water use.

It should be noted that these results may not apply to other states. The Northwest Ordinance and Wisconsin Constitution guarantee Wisconsinites free use of navigable water. The DNR in Wisconsin has vigorously enforced the public rights in water; the state role has been especially strong in Wisconsin, in regulating use of the water and associated shorelands.

In other states, the expected role of the federal government may be greater as it apparently became along White Clay Lake residents.

Table 11.3--Mean Rank for Who Should Pay for Maintaining or Improving Lake Water Quality [a]

	Statewide	White Clay Lake Residents	Waupaca Residents	Shadow Lake Recreationists	White Clay Lake Recreationists
Lake Property Owner	4.0	4.5	3.7	4.0	4.0
Visitor	4.0	4.0	3.9	4.0	3.8
Polluter	2.0	2.2	1.8	2.1	2.0
Local Government	3.6	4.1	3.8	3.0	3.6
State Government	3.2	2.9	3.1	3.5	3.2
Federal Government	4.1	2.9	4.5	4.3	4.2
(N)[b]	(1342)	(35)	(140)	(57)	(62)

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[a] The lower the number, the higher the rank (range 1-6).

[b] Missing data may reduce N somewhat in particular categories.

Residents of other states may also be willing to accept a user charge for water.

Wisconsin Cost Sharing. Wisconsin is one of the few states to provide state cost sharing for lake management. The cost sharing was initiated as part of the Wisconsin lake management program started in 1974. It is consistent with a strong state role in water quality management in Wisconsin.

Chapter 33 requires that at least 10 percent of the cost be borne locally unless an experimental effort dictates that the state pick up 100 percent of the costs. In the process of developing the administrative codes (NR 60), the Wisconsin Inland Lake Protection and Rehabilitation Council advised a cost-share rate less than the 90 percent allowed by law.

The Council is composed of four citizens appointed by the Governor and five agency heads (DNR; Department of Development; Board of Soil and Water Conservation; Department of Agriculture, Trade and Consumer Protection; and University of Wisconsin-Water Resources Center). Its role is to advise the DNR on program policy.

After some changes, the state cost-share rates were pegged at:

- 60 percent for feasibility studies conducted by a private consultant, selected as the lowest responsible bidder by the lake district, using the DNR study specifications;
- 80 percent for implementation of DNR approved projects;
- 30 percent for large projects which are also receiving EPA cost sharing at 50 percent; and
- No project can receive more than 10 percent of the state money available in a given year (maximum state grants vary from $100,000 to $200,000 depending on the year of the biennial budget).

The 10 percent limit is statutory and has occasionally hampered state response to cost sharing of large projects.

Lake districts are allowed in-kind credit for work they do on a project. The credit has been popular with lake districts with small tax bases. However, it has sometimes been abused by consultants who promised to allow the district 40 percent of in-kind work but indirectly charged the state for an inflated 60 percent.

It should be noted that in most other states, the state role in both financial and technical assistance is more limited. Private consultants are providing more technical assistance and local communities are providing larger shares of the dollars. The number of communities involved in lake management is also significantly less in other states.

Private Gain from Public Cost Sharing. The decision to cost share projects at 80 percent has not been without challenge. Some people would like to vary the cost-share rate depending on the project. Some projects have more public benefits. Some lakes are more important to the public because of proximity of population centers, lack of other lakes, proximity to other attractions, or uniqueness of the lake. Some communities have more ability to pay and have less need for cost sharing. If requests exceed funds available, a priority system is necessary or the cost share for each lake would drop. The Council advised DNR that a priority system was better than diluting the cost-share rate.

So far Wisconsin and federal programs have opted for consistent cost-share rates. That policy is firm except for a serious review with regard to projects installed on private land in the watershed, i.e., manure storage facilities.

The review was prompted by the differing cost share rates of other watershed management programs (Wisconsin Fund, Agricultural Stabilization and Conservation Service Programs, County programs). To the extent that landowners feel government doesn't "have its act together," the variable rates are bad. To the extent that different rules of eligibility and cost-share rates allow flexibility in orchestrating a project, they are good.

Another reason for the challenge was based on construction of improvements on private land. These improvements increase the value of property and increase the efficiency of the farm operation. This challenge has been discussed in regard to White Clay Lake in Chapter 10.

The manure storage facilities built on farms around White Clay Lake reduce pollution to the lake. They also reduce wear and tear on farm equipment that would otherwise be used to spread manure on cold winter mornings. Fertilizer value is salvaged. Farmers have time for other tasks without daily manure handling.

Many other farmers are beginning to follow the White Clay Lake example by installing manure storage facilities without public cost sharing. These farmers believe the facilities are worth the entire cost in private benefits.

Because of the project's experimental nature in 1975, the White Clay Lake District received 90 percent cost sharing for the project. In-depth interviews were conducted with nine dairy farmers. The farmers believed they got a good deal. In fact, the farmers would have been willing to pay from 25-80 percent as their cost share. The average farmer in the sample would have been willing to pay about 50 percent. However, seven of the nine farmers said 10 percent was a fair share for them to pay for water quality projects. The dominance of the 10 percent figure is likely due to the knowledge among the farmers that they had contributed exactly that amount, or that ten percent was not "unfair."

Participant willingness to pay is directly related to the perceived worthiness of the project. Farmers were interested in the project for business reasons. Two-thirds of the farmers were motivated by the improved nutrient retention on land made possible by the new manure handling system. Some farmers said they no longer had to worry about spreading manure in deep snow or on soft ground. Several farmers also mentioned that their new concrete barnyards (part of the manure handling system) made their work easier and kept their cows healthier. Roughly half of the farmers said lake protection was a reason for installing the manure handling systems.

The Optimal Cost-Share Rate. With cost share levels at 90 percent, it should be possible to attain a high rate of participation in a given area. However, 90 percent cost-share levels are not always possible. When money is short, and a program's geographic coverage is wide, a lower level of cost sharing by the agency may be required. Principles of equity may also demand a lower level.

This study has shown a break-even cost share rate for the farmer at White Clay Lake would have been between 32 and 40 percent. Such research sophistication must be tempered with administrative and political consideration. A cost share of 50 percent would seem reasonable.

FOOTNOTES

1. The 40,132 user count was arrived at in the following manner. Lifeguards took a morning and afternoon count, added them together and doubled the sum to arrive at a daily user count for boaters, swimmers and fishers. This method had been employed by the Director of the Waupaca Department of Recreation, not only while he had worked in Waupaca but also during his employment in the Milwaukee Department of Recreation. These daily counts were taken June 22 - August 22, 1978. Since the beaches were actually open from June 1 - September 30, estimates were provided for the two periods before and after the counts.

User counts (June 22 - August 22)	22,704
Estimated June 1 - June 21) 15 weekdays @100/day and 6 weekend days @400/day	3,900
Estimated (August 23 - September 30) 25 weekdays @ 60/day and 10 weekend days @ 240/day	3,900
Total for open water fishing, swimming, boating, 1978	30,504

A 1978 telephone survey of Waupaca residents revealed that 76 percent of the reported lake use was for swimming, open water fishing and boating, while 24 percent of uses went for picnics and ice-fishing during the winter. Since picnics and ice fishermen were not included in the daily user counts provided by the life-guards, their counts were expanded 24 percent. Total annual use of Shadow Lake for the year 1978 was estimated at 40,132. On-site interviews estimated that of this total approximately 15 percent were out-of-town users. Consequently, two representation rates were used; one based on 34,112 annual visits by Waupaca residents and the other based on 6,020 out-of-town users.

2. The 1968 count of 76,026 was determined in the same manner. The life guard counts for boaters, swimmers and fishers (June 1 - September 30) was 57,780 which was assumed as in the previous case to represent 76 percent of total lake use. Expanding to account for picnicking and ice-fishing brought the estimated, total annual use of Shadow Lake to 76,026. Two representation rates were again used; one based on 64,622 annual visits by Waupaca residents and the other based on 11,404 out-of-town users.
3. Freeman, in his text published after this analysis was conducted, takes issue with this specification (13). However, this ad hoc model provides results that appear reasonable when compared to the recreation benefit estimates as will be demonstrated in Chapter 9.
4. McMillan also argues that property values might underestimate benefits as increased taxes due to higher property values will be capitalized into the price of the property.
5. On-site interview at Shadow Lake in Waupaca revealed that approximately fifteen percent of the recreators were nonlocals.
6. To use consumer surplus as a measure of resource value it is necessary to make two basic assumptions. First, that all other prices other than the good in question are held constant. And second, that the benefits do not change the real income of the beneficiaries. In other words, the area under the demand curve reflects the Marshallian measure of consumer surplus. However, research by Willig has demonstrated that the above assumptions are not that restrictive that they should invalidate the resulting estimates of consumer surplus (69). He states that in those instances where the consumer's income elasticity is in the range of ±1.0,

and "if the surplus area under the demand curve between the old and new prices is 5 percent of income (or less), then the compensating variation is within 2 percent of the measured consumer's surplus." Certainly both of these assumptions are realistic for the case at hand.

7. The use of lower cost figures, other variable values remaining the same, yields more elastic demand curve estimates and consequently smaller accompanying resource values.

8. The wage rate for housewives and students was set equal to the state minimum wage of $2.55 per hour (August 1977).

9. It is necessary to assume that the demand functions are aggregates of homogenous groups of recreators, i.e., similar tastes and preferences, react the same to price changes, etc. (29). However, this assumption is mitigated by the use of individual observations (16), p. 564).

10. For comparison purposes only the benefits discounted at 7-1/8 percent are used.

11. Annual user counts for White Clay Lake were provided by user counts taken in the morning and late afternoon-evening and then summing the two.

12. Another benefit of the less-polluting handling techniques was identified in interviews with farmers. Since outdoor work in the winter is frequently uncomfortable, as well as being somewhat harder on equipment, the pollution-reducing technique which does not require winter spreading has an advantage over the daily handling method, which requires spreading during the winter season. Unfortunately, the model was not equipped to assess the magnitude of this benefit because labor was treated as a homogenous resource throughout the year.

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